THE
BRITISH JOURNAL OF SURGERY

VOL. XXXVIII JANUARY, 1951 No. 151

BENIGN GIANT-CELL SYNOVIOMA

AN INVESTIGATION OF 85 CASES

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THE benign giant-cell synovioma is still referred to in recent literature by a variety of terms such as myeloid or giant-cell tumour of tendon-sheaths, xanthomatous giant-cell tumour, villonodular synovitis, and xanthoma of tendon-sheaths and synovial membranes. The use of these other terms is unsatisfactory and some are completely at variance with the true nature of the growth. The benign giant-cell synovioma, which must certainly be regarded as neoplastic, always arises from synovial membrane and should therefore be called a synovioma. At present this term often carries only a malignant connotation and I would like to suggest that all malignant forms of synovioma should be so labelled. In a substantial proportion of cases the benign giant-cell synovioma probably does not arise from tendon-sheaths but from joints, although the mode of development in each form is exactly analogous. Benign giant-cell synovioma and malignant synovioma have been regarded as entirely separate conditions, but while they are certainly different in some respects, it is not generally realized that they are closely related histologically and that all stages can in fact be traced between the two. This merging is both with the ordinary malignant synovioma and with its rare variant the malignant giant-cell synovioma, a tumour which undoubtedly does exist. The essential characteristic of all synovial tumours—differentiation into synovial spaces—is present in both the benign and the malignant forms. Malignant synovioma is more common than was at one time thought and is now being recognized and diagnosed with greater frequency. I have been unable to find any record in the literature of a case of typical benign giant-cell synovioma which has metastasized, and no such case exists in this series.

FIG. 372.—A benign giant-cell synovioma of the thumb to show the encapsulation and characteristic lobulation. (× 2·5.)

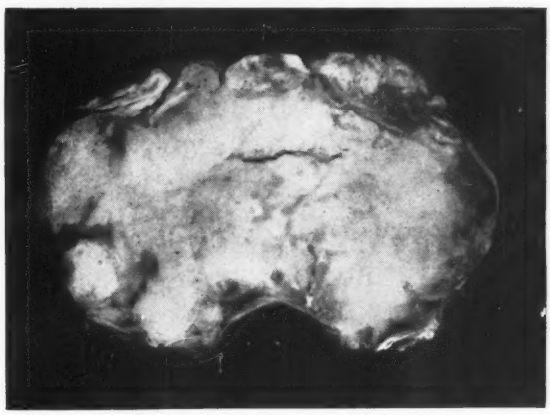

FIG. 373.—Transverse section of a benign giant-cell synovioma of tendon-sheath to show the groove in which the flexor tendon lay. (× 2·4.)

The tumours included in the benign giant-cell synovioma group belong to a fairly clear-cut category, but, even so, they show all gradations from the typical benign tumour to a more cellular variety of intermediate histological malignancy, which in turn is closely related to malignant synovioma. The features which the group have in common are: an indefinite period of freedom from metastases; lack of, or virtual lack of, local infiltration; similarity of structure; and characteristic sites of occurrence.

This investigation is based on a review of 85 cases of benign giant-cell synovioma, of which 55 are from records of the Leeds General Infirmary covering the period 1910–49, and 30 are from hospitals in the neighbourhood—mainly cases referred by pathologists to Professor Stewart. Histological material was available from 81 of these cases. Of

the other 4 cases, 2 have already been published. The gross tumour specimen has been personally studied in 23 cases, including 3 in which a finger was amputated.

Age Distribution.—The age is known in 76 cases, and, of these, 62 (82 per cent) are in the 20–59 age group (*Table I*). The average age is 38·5 years, but as the average duration of the tumours when the patients were first seen was $2\frac{7}{12}$ years, the average age at onset is 36 years. Galloway, Broders, and Ghormley (1940) found an average age of 44 years in their own series of 70 cases and 37·5 years in 223 cases collected from the literature.

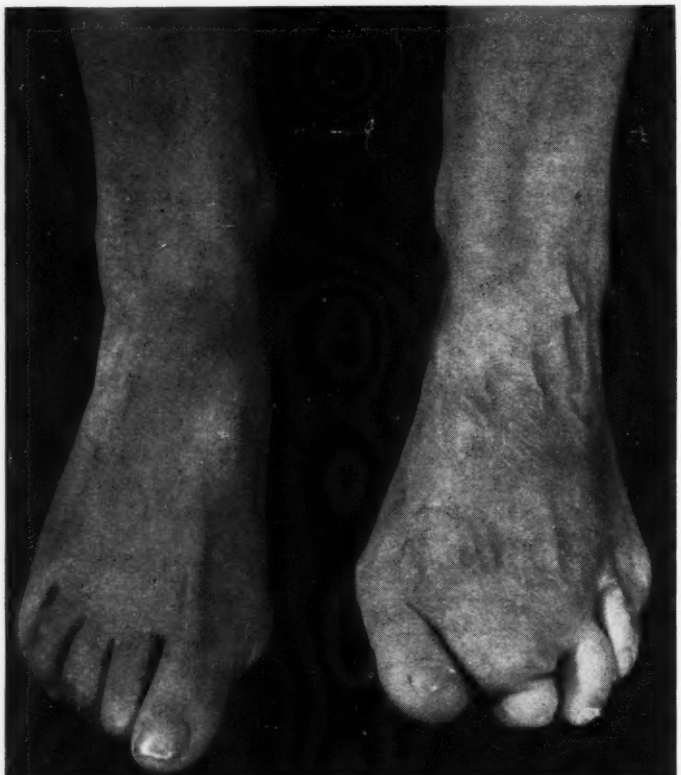

FIG. 374.—Recurrent benign giant-cell synovioma of the left foot of nine years' duration.

Sex Distribution.—In this series the tumour was of more frequent occurrence in women. Of 82 cases, 55 (67 per cent) were females. Galloway and others found that 71 per cent of their own series were females, but only 55 per cent of their collected cases.

Table I.—AGE DISTRIBUTION AT THE TIME OF FIRST OPERATION IN 76 CASES OF BENIGN GIANT-CELL SYNOVIOMA

Age periods	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79
Number	1	7	15	17	15	15	5	1

Youngest 8 years; oldest 72 years; average 38·5 years.

Sites of Occurrence.—These are as follows:—

SITES OF 80 CASES OF BENIGN GIANT-CELL SYNOVIOMA

Upper limb, 69 cases (86 per cent)			*Lower limb, 11 cases (14 per cent)*	
Thumb		12	Toe	1
Fingers		44	Foot	2
Index	10		Ankle	1
Middle	11		Knee (para-articular)	2
Ring	5		Knee-joint	5
Little	6			
Not stated	12			
Palm of hand		9		
Dorsum of hand		2		
Wrist (anterior aspect)		2		

The exact site on the palm of the hand is known in 8 cases—all overlay metacarpo-phalangeal joints, 3 each at the root of the index and middle fingers, and 2 at the root of the little finger. One of the two tumours on the dorsum of the hand was situated over the first metacarpal bone near the wrist, and the other over the 5th metacarpal bone, also near the wrist.

The site of election of the benign giant-cell synovioma is the hand (86 per cent) and particularly the digits. The tumour is usually stated to occur 'almost invariably' on the flexor aspect of the digit. This would, however, appear to be a completely erroneous impression, since of 58 cases in this series where the tumour was situated on the hand and where the relationship to the tendons was known, 25 were flexor, 24 extensor, and 9 lateral. The findings of Galloway and others are in accord with these results. Of their tumours involving the fingers, 20 were flexor, 17 extensor, and 7 lateral. In 3 cases of the present series, recurrences involved both flexor and extensor aspects. The left hand was affected as frequently as the right.

Duration of Growth before Primary Operation.—The duration of the growth before the primary operation was known in 63 cases and ranged from 3 months to 10 years, with an average of $2\frac{7}{12}$ years (*Table II*). It is usually considered that the tumours are of slow growth, and while this may be true in many instances, in 65 per cent of this series the duration was less than two years. In addition, tumours which have grown slowly over a fairly long period may then grow more rapidly. In others, rapid growth takes place from the beginning; in 9 cases the history was of less than six months' duration.

Table II.—DURATION OF GROWTH BEFORE PRIMARY OPERATION IN 63 CASES OF BENIGN GIANT-CELL SYNOVIOMA

Duration (years)	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10
Number	20	21	7	3	4	3	1	3	0	1

Shortest $\frac{3}{12}$ year; longest 10 years; average $2\frac{7}{12}$ years.

Injury as a Causative Factor.—In many cases there does seem to be a definite association between injury and subsequent tumour formation. Information as to injury was only available in 48 cases, but

of these, 19 (40 per cent) gave a history of trauma to the site of growth. Examples include tumours

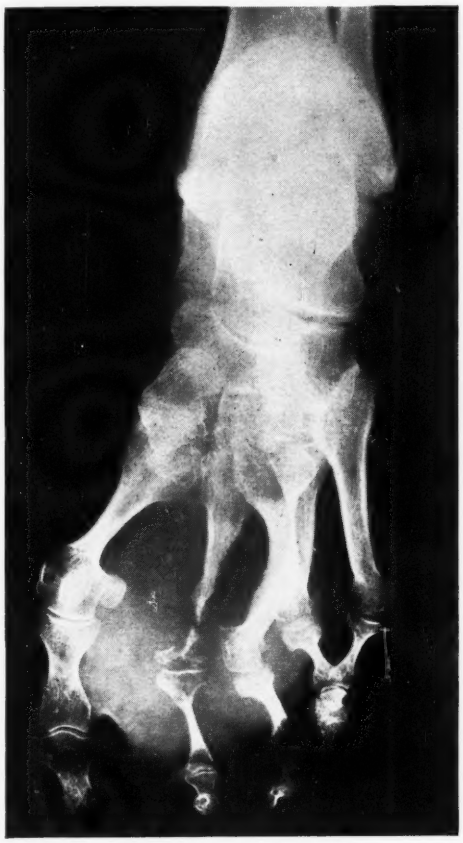

FIG. 375.—Radiograph of the affected foot in *Fig.* 374, showing large soft-tissue tumour mass with long-standing secondary trophic and pressure changes in the bones.

arising at the sites of the following: hook driven into finger; cut with glass (2 cases); stab from knitting needle (Grant and Stewart, 1914); saw injury to thumb (Stewart and Flint, 1915, Case 1); and injury to wrist (2 cases, including Stewart and Flint's Case 2). In addition to the 19, a further 9 cases gave a history of possible trauma to the site. In the other 20, injury of any sort was denied.

MORBID ANATOMY

The benign giant-cell synovioma may arise from tendon-sheaths, joints, or bursæ and, except when it involves the large joints, tends to be largely encapsulated, roughly ovoid or rounded, and usually characteristically lobulated (*Fig.* 372). The tumour is almost invariably very firm, but the largest ones are occasionally soft as, for example, the two tumours in this series situated on the wrist. When flexor tumours of the digits reach a substantial size they frequently have a groove in which the flexor-tendon lay (*Fig.* 373). The benign giant-cell synovioma is basically grey in colour, but commonly shows varying amounts of yellow and brown pigment; the yellow due to lipoid, the brown to hæmosiderin. The variation in lipoid content among the tumours is great, ranging from none visible to the naked eye to almost the whole growth being yellow in colour. Siderosis is also variable and is often especially noticeable around the periphery and on the synovial surfaces. The tumours rarely attain a large size, particularly when situated on the hand, their commonest site, ranging from a few mm. to about 2–3 cm. in diameter. Elsewhere, especially on the foot, they may be much larger; a recurrent tumour in this series situated on the wrist (Stewart and Wright,

FIG. 376.—Section of benign giant-cell synovioma with tenuously attached tiny outlying nodule of tumour tissue. (× 7·2.)

1950) measured 7·5 × 6 × over 2·5 cm. and three of the four tumours situated on the foot were also of considerable size (*Figs.* 374, 375). A distinctive feature of the benign giant-cell synovioma is its lobulation, which may take the form of a nodularity of the surface (*Fig.* 372), or the tumour may consist of a number of separate nodules held together by strands of fibrous tissue. Sometimes one or two tiny nodules are only tenuously attached to the main tumour (*Fig.* 376) and extreme examples consist of a large number of small nodules strung together (*Fig.* 377).

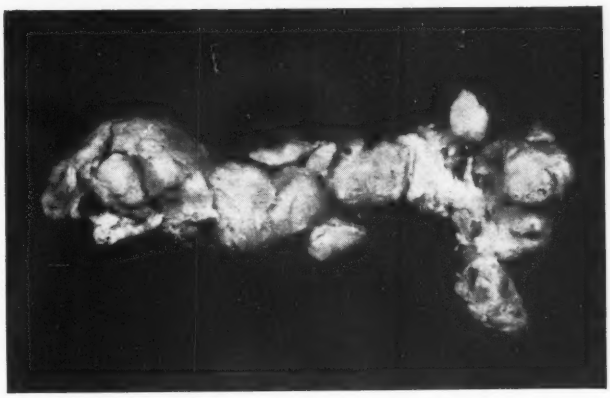

FIG. 377.—Benign giant-cell synovioma formed of a large number of small nodules strung together. (× 2·2.)

At operation the tumours usually appeared well encapsulated on their superficial aspect, but careful examination revealed attachment to deep structures. In three cases there was inseparable attachment to the overlying skin.

The deep attachment of the benign giant-cell synovioma has received scant attention in the past,

but it is of great importance both in the understanding of the origin and nature of the growth and in treatment. The deep attachments are of most interest in the hand, as this is the most common site of the tumour. Every benign giant-cell synovioma is considered to have arisen from normally existing synovial membrane and it is clear that the flexor tumours could have arisen from the flexor tendon synovial sheaths. Even the tumours in this series which were situated on the palm of the hand

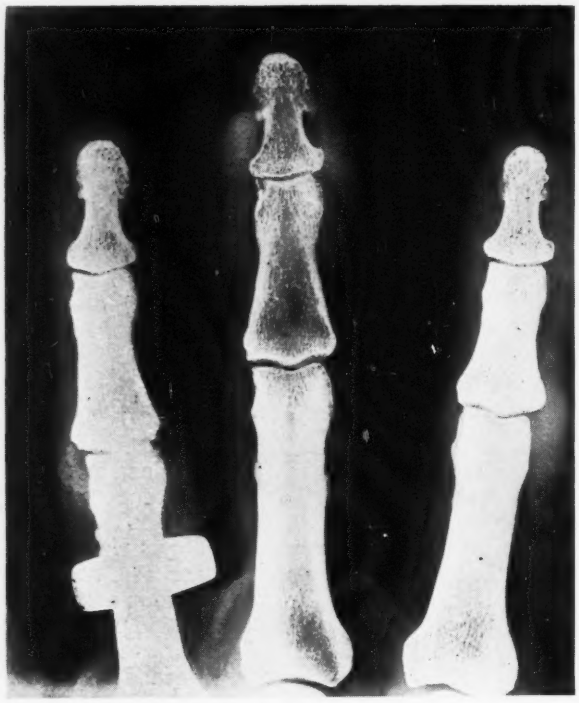

FIG. 378.—Radiograph of the tumour in *Fig.* 377 before its excision. It is situated over the extensor aspect of the distal interphalangeal joint of the left middle finger.

were distributed only where there is synovial membrane, which is of course absent from the centre of the palm.

The extensor aspect of the digits was as frequently involved as the flexor, and a different mode of origin for the tumour is therefore necessary since the extensor tendons of the digits are devoid of synovial membrane. The possibilities to be considered are either that the tumour has arisen from the flexor tendon-sheath and has remained attached to it by a pedicle, or, more likely, that it has arisen from the synovia of the phalangeal joints. On the extensor aspect the tumours were in fact all related to joints (*Figs.* 378–380), most frequently the distal interphalangeal. The exact position of 17 of the 24 extensor tumours is known. One was attached to the synovial sheath of extensor pollicis longus and another to that of extensor digiti minimi, in both cases near the wrist. The others were all related to interphalangeal joints—3 on the thumb (*Figs.* 379, 380), and 3 to proximal and 9 to distal joints (*Fig.* 378) of fingers. The tumour was either directly over the joint (*Fig.* 378) or immediately proximal to it (*Figs.* 379, 380) and often slightly to one side of the midline (*Fig.* 379).

In all the interphalangeal joints there is a fairly long proximal dorsal prolongation of the synovial

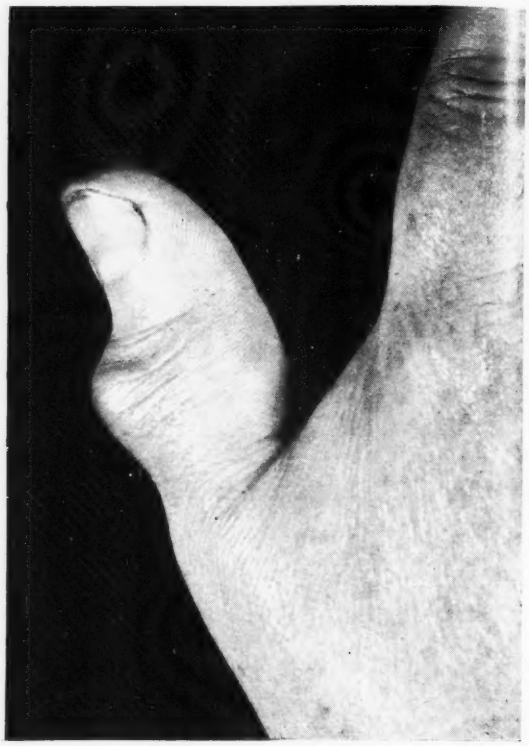

FIG. 379.—Benign giant-cell synovioma of the thumb. The tumour is situated over the extensor aspect of the interphalangeal joint, slightly to the radial side.

sac beneath the extensor tendon. The extensor tumours most probably always originate from this

FIG. 380.—Radiograph of thumb in *Fig.* 379 to show that the tumour is immediately proximal to the joint.

and the growth will of necessity be outwards rather than into the joint cavity as this is so small. The

extensor tendon is the only external restriction and the tumour will consequently at first lie deep to the tendon, but usually penetrates it or extends around it. Operative details in several instances revealed that the joint cavity was known to have been opened in excising the tumour. When the tumour involves the proximal interphalangeal joint it will of necessity

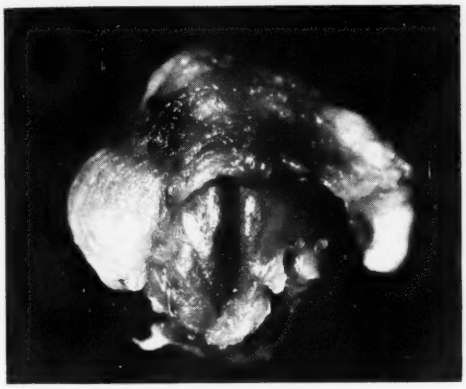

FIG. 381.—Benign giant-cell synovioma from extensor aspect of proximal interphalangeal joint of left ring finger to show the smooth shiny synovial under-surface with cut edges of synovial-membrane-lined pedicle which had communicated with the joint. (× 2·9.)

have to arise deep to the extensor tendon expansion owing to the width of this structure at this point. Two such tumours were described as being situated deep to the tendon, in one case related to the interphalangeal joint of the thumb and in the other to the proximal interphalangeal joint of a finger. In two further cases (*Figs.* 381, 382) the tumour was

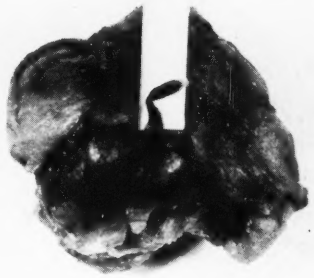

FIG. 382.—Same tumour as *Fig.* 381 but showing pigmented papillary tumour process arising from the synovial surface and projecting into the pedicle. (× 2·6.)

superficial to the tendon and communicated with the joint by a long, hollow, synovial-lined pedicle which either curved around or penetrated the tendon. The extensor tendon is much narrower over the distal joint and it would be easily possible for the tumour to extend around either side. Examination of a finger amputated for a recurrent tumour which involved both extensor and flexor aspects (*Figs.* 383–386) revealed continuity between the distal interphalangeal joint cavity and a synovial cavity within the extensor tumour (*Figs.* 383, 384, and 386). This tumour, which no doubt arose from the proximal dorsal synovial prolongation of the joint cavity, was partly deep to the extensor tendon and partly superficial to it (*Fig.* 383) and also extended around one

FIG. 383.—Longitudinal section of finger amputated for recurrent benign giant-cell synovioma which is arising from the distal interphalangeal joint synovium and is involving both extensor and flexor aspects. , Note cavity within extensor growth continuous with proximal dorsal synovial prolongation of the joint cavity. The extensor growth is partly deep to and partly superficial to the dorsal tendon. The patient is still alive 23 years later. (× 1·35.)

side of the finger (*Fig.* 385) to form a large nodule of growth on the flexor aspect. This was superficial to the flexor tendon-sheath, but only loosely attached to it (*Fig.* 383).

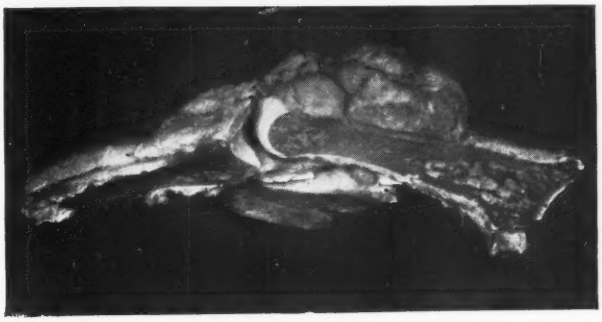

FIG. 384.—Same finger (other half) as *Fig.* 383, to show the continuity between the distal interphalangeal joint cavity and the synovial cavity within the extensor tumour (the roof of the cavity as a whole, has been removed). (× 1·7.)

Careful examination of several of the excised tumours revealed a free, shiny, synovial surface on

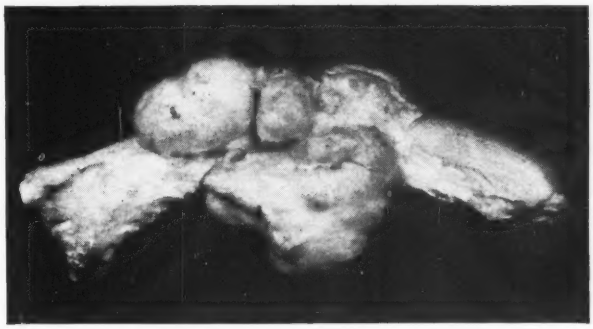

FIG. 385.—Lateral view of finger in *Fig.* 384. The tumour, which is lobulated, extends around this side of the finger on to the flexor aspect. (× 1·6.)

the deep aspect with attached synovial membrane at its margins (*Fig.* 381). This surface was brown

in colour and the cut edges of the synovial membrane could be clearly seen (*Figs.* 381, 387). Two extensor tumours showed, particularly near the cut edges of this synovial surface where the normal synovial membrane blended with the tumour, fine, often elongated, brown papillary tumour processes sometimes folded upon themselves (*Figs.* 382, 387). They had apparently projected into the cavity of the

FIG. 386.—Photomicrograph of extensor tumour of same case as *Figs.* 383–385 to show the synovial cavity within the tumour with papillary tumour processes projecting into it. The cavity communicated with the distal interphalangeal joint. Note invasion by the tumour of the overlying skin. (× 7·2.)

pedicle, which in turn communicated with the adjacent joint cavity.

The laterally disposed tumours may either have arisen from joints or tendon-sheaths; at least 4 of

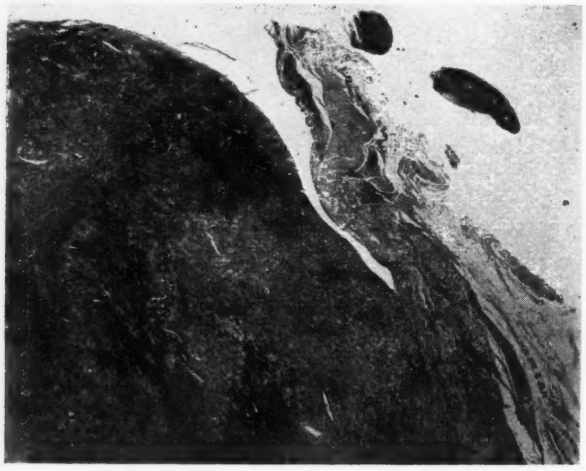

FIG. 387.—Photomicrograph of same tumour as *Figs.* 381, 382, to show the synovial surface of the tumour, attached synovial membrane at its margin and papillary tumour process (this has been unfolded—it was actually within the synovial membrane fold). Note the small deposit of growth in the synovial membrane just within the line of excision. (× 12·6.)

the 9 are known to have been situated opposite joints.

The flexor tumours (*Fig.* 388) arise from the synovial membrane of the tendon-sheath, and, in the course of their growth, owing to lack of space within the synovial sac, burst through the outer coverings of the sheath (*Fig.* 389) as an encapsulated tumour which remains attached to the sheath. They are thus similar in character to the extensor tumours. In two of the flexor tumours, for example, there was a deep groove which had contained the flexor tendon (*Figs.* 373, 389). This groove was found to be lined by shiny synovial membrane which merged with the tumour tissue and, in one instance, tiny

FIG. 388.—Radiograph of benign giant-cell synovioma of the flexor tendon-sheath of a finger.

brown papilliferous tumour processes projected. A further case was unusual and of great interest; a finger which had been amputated following incomplete excision of a recurrent tumour situated over

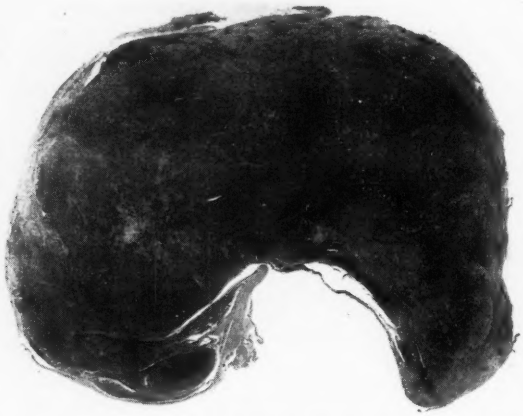

FIG. 389.—Section of benign giant-cell synovioma of flexor tendon-sheath with deep notch for the flexor tendon. The tumour has burst through the sheath, the remains of which can be seen on the left, together with its synovial membrane lining. (× 4·5.)

the flexor tendon-sheath, showed, on opening the sheath, multiple tumour processes arising from the synovial lining and projecting into the cavity (*Fig.* 390). Deep to the site of the recurrent tumour itself was an early second recurrence which was brown and papillary on its synovial aspect and encapsulated above (*Fig.* 391, top). The primary growth and first recurrence had presumably grown outwards at this site, between two thick fibrous sheath ligaments. On the synovial surface immediately adjacent to this area were two elongated,

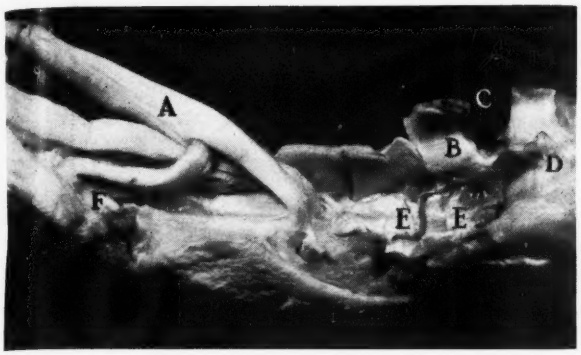

FIG. 390.—Finger amputated following incomplete excision of recurrent benign giant-cell synovioma of flexor tendon-sheath. This sheath has been opened and the tendon (**A**) lifted from its bed and retracted distally. The wall of the sheath (**B**) has been reflected outwards and **C** is the site of the second recurrence shown microscopically in *Fig.* 391. Tumour processes arising from the synovial lining of the sheath and projecting into its cavity are shown at **D** and **E** (a portion has been removed from the centre of this process, which lay beneath the tendon). Numerous tiny brown papillary tumour processes were present in area **F**. (× 0·9.)

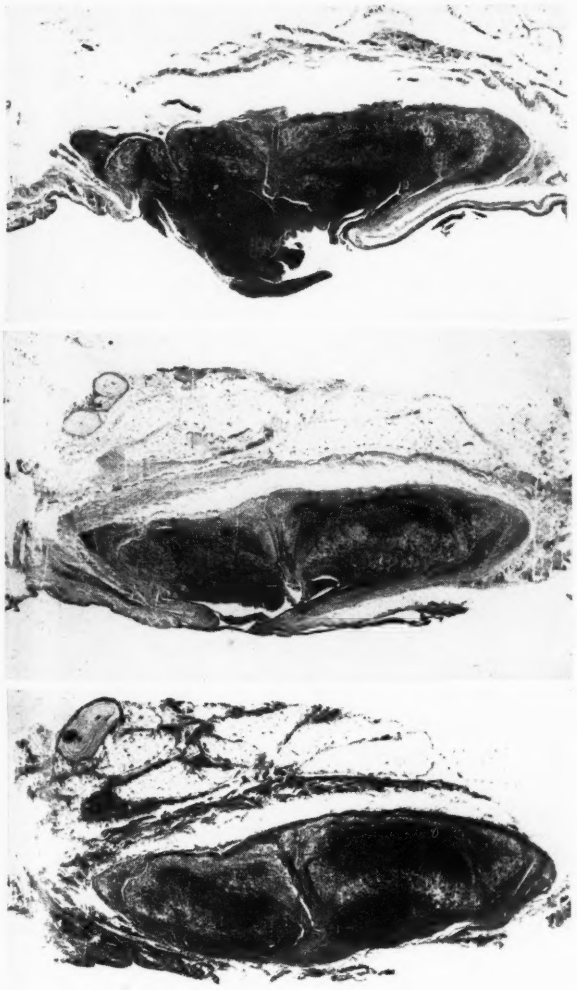

FIG. 391.—Three photomicrographs at different levels of early second recurrence found at operation site of finger shown in *Fig.* 390 (from area **C**). The tumour is papillary on the synovial aspect and encapsulated above (top). These three sections illustrate the probable development sequence as the tumour becomes separated from its synovial origin. (× 9.)

papillary, tumour processes, one brown and fairly substantial, the other yellow and filamentous (*Fig.* 390, **D**). Between the tendon and the bone was a third process mainly yellow and of considerable size but flattened (*Fig.* 390, **E**). Further along the sheath towards the distal end there were numerous tiny brown papillary tumour processes deep to and to one side of the tendon (*Fig.* 390, **F**). The whole appearance was exactly comparable to the benign giant-cell synovioma of the knee-joint.

Rarefaction of adjacent bone may be produced by pressure and consequently occurs especially with tumours of the foot (*Fig.* 392); in one such case

FIG. 392.—Radiograph of foot to show benign giant-cell synovioma of the fourth toe with rarefaction of the adjacent middle phalanx and proximal part of distal phalanx.

there was gross distortion and pressure atrophy of the bones (*Figs.* 374, 375).

Benign giant-cell synovioma situated elsewhere than the hand is rare In the knee-joint the tumour differs only in that it is almost invariably papillary (*Fig.* 393) as, owing to the relatively large joint space, the growth occurs into the cavity rather than outwards, as in tumours of the hand. The tumour, which may be either polypoid (*Fig.* 393) or villous, is frequently diffuse or multiple within the synovial sac and the processes are brown or yellow in colour. Four of the five cases in this series were polypoid and three of them also presented as loose bodies in the joint. In one case a solitary loose body the size of an almond was found and in another there were ten ranging in size up to 2 × 1 × 1 cm. The third case had a solitary tumour the size of a cherry and, although this behaved as a loose body, it was attached by a long fibrous pedicle to one of the alar ligaments. In the fourth the tumour (*Fig.* 393) was an apparently

localized polypoidal area measuring 2 × 2 cm. which, although it was thought to have been completely excised, subsequently recurred. The remaining example first manifested itself in a semimembranosus bursa which was found to communicate with

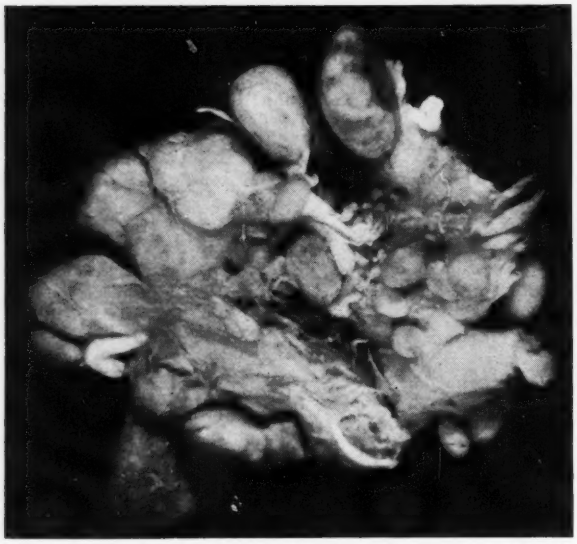

FIG. 393.—Polypoidal benign giant-cell synovioma of the knee-joint. This specimen was thought at operation to be the entire growth, but there was subsequent recurrence. (× 2·4.)

the knee-joint; subsequent exploration of the joint showed that the synovial surface was completely lined by brown frond-like structures with a separate small pedunculated swelling, the size of a pea, in the intercondyloid space.

HISTOLOGY

The general structure of the benign giant-cell synovioma is typical and well known (*Fig.* 394), but

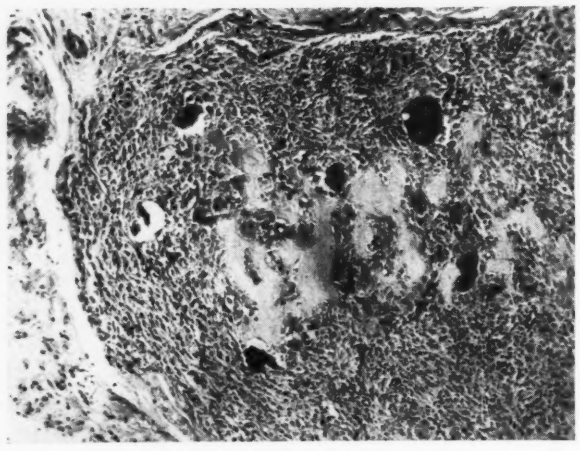

FIG. 394.—The characteristic microscopical structure of the benign giant-cell synovioma. (× 73.)

there are certain features which are apparently not widely recognized although they are of much significance. Synovial tumours show both hyalic and lepidic elements, often with an intimate blending of the two. The benign giant-cell synovioma is formed essentially of polygonal synovial cells, arranged both in groups and singly, set in a fibrous collagenous stroma often much hyalinized; there is an insensible merging of the two kinds of tissue, the polygonal synovial cells becoming fibroblastic. Closely associated with the synovial cells and derived from them

FIG. 395.—Section of a benign giant-cell synovioma of the more cellular type, but with numerous large spaces lined by synovial cells. Several of the spaces contain foamy cells, some of giant type. Note absence of ordinary giant cells in this field. Primary tumour from same case as *Figs.* 374, 375. (× 54.)

presumably by fusion are multinucleated tumour giant cells of osteoclast type; they are of varying size, usually fairly large, and are present in varying numbers and are of irregular distribution. Giant cells were present in every case, but in the more cellular tumours they were often few in number, whereas in more typical examples they sometimes almost dominated the picture. The giant cells are seldom as numerous or as large as in osteoclastoma and are more focally distributed; the rest of the tissue is also quite different. Lipoid and hæmosiderin deposits are other common features. The lipoid is almost invariably intracellular, in the form of foamy-cell aggregations which are most probably usually tumour cells rather than non-neoplastic macrophages. An occasional Touton giant-cell or foamy giant-cell (*Fig.* 395) may be found. Rarely the tumour may be exceedingly xanthomatous, with numerous xanthomatous giant cells, although otherwise still conforming with the general structure of benign giant-cell synovioma. Moderate to heavy xanthic change was found in only 25 of 81 tumours. In a few tumours deposits of free (tabular) crystalline cholesterol were present, usually within degenerative foci. Siderosis was noted especially around the periphery and on synovial surfaces, but was sometimes generalized and occasionally restricted to the centre of the tumour. Moderate to heavy siderosis was found in 15 of 81 tumours.

Differentiation into Synovial-lined Spaces.—The synovial cells forming the benign giant-cell synovioma have a highly characteristic tendency to form glandular spaces—in fact, synovial differentiation is the most characteristic histological feature of all synovial tumours, both benign and malignant.

These spaces were present in varying degree and in varying numbers in nearly all the 81 cases in which histological sections were available for study. Further sections of the few tumours where definite spaces could not be found might well have revealed them.

In the past little attention has been paid to synovial spaces in the benign synovioma and they have not often been recognized. They were described and clearly illustrated by Bellamy (1901), who, however, regarded them as blood-vascular spaces lined by proliferating endothelium and often containing giant cells. He quotes Venot as having in 1898 made the sole previous observation of this phenomenon. King (1931) stated that he found definite spaces in all the tumours he examined. In 1938 Berger mentioned the spaces, but seems only to have encountered them once in his series of 11 cases. Ragins and Shively (1939) noted cleft formation in 22 of their 23 tumours. Galloway, Broders, and Ghormley (1940) made no mention whatever of synovial spaces, either in their own series of 70 cases or in their review of cases from the literature. Jaffe, Lichtenstein, and Sutro (1941) made reference to the spaces, but more recently Foster (1947), who considers the tumour to be a sclerosing hæmangioma, merely mentions the presence of poorly defined vascular channels in some of his 42 cases.

In the benign giant-cell synovioma these glandular spaces in the ordinary paraffin sections usually show no sign of any secretion. Synovial spaces form in the first place as either signet-ring vacuoles or more usually as clear vacuoles around individual cells (*Fig.* 396), the cell being in the centre and having a clear-cut cytoplasmic outline with occasional strands of cytoplasm extending to the edge of the vacuole. Where the synovial cells are arranged in groups the vacuoles formed by adjacent cells coalesce and eventually the central cells tend to disappear, leaving the characteristic glandular spaces (*Fig.* 396). Berger's observations pointed to a similar mechanism. King considered that the spaces were preceded by a condensation of cells along a definite line, followed by cleavage and cleft formation. This probably does occur occasionally (*Fig.* 397), but some of the spaces he figures are quite likely to be of another kind, i.e., developmental rather than due to differentiation. Synovial spaces are usually rounded, oval, or of irregular shape (*Figs.* 395, 396), but may certainly appear as clefts (*Fig.* 397). The

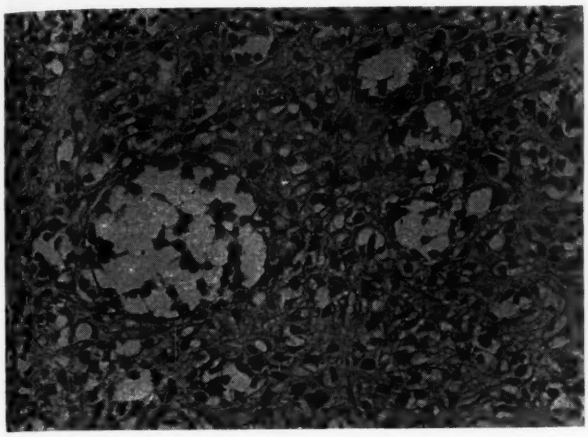

FIG. 396.—Illustrating the usual mode of development of the synovial space in benign giant-cell synovioma. (× 180.)

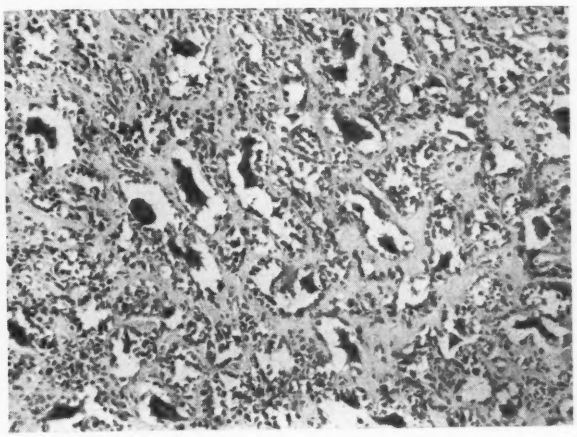

FIG. 398.—Section of a benign giant-cell synovioma of the foot to show numerous synovial spaces, with giant cells included among the lining cells and projecting into the lumina. (× 72.)

FIG. 397.—Section of benign giant-cell synovioma to show the occasional appearance of the differentiated synovial spaces as clefts. (× 50.)

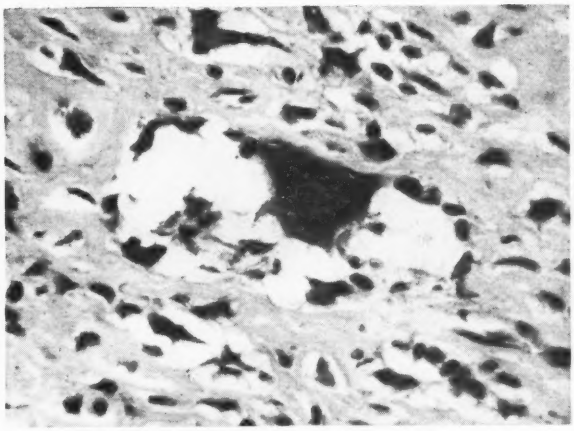

FIG. 399.—High-power view of a synovial space with giant cell forming part of the lepidic lining. (× 352·5.)

cells lining the spaces are usually rounded or cuboidal, but may be rather flattened or occasionally columnar. The benign giant-cell synovioma may contain only scattered small spaces or the spaces may be numerous, in some cases the most prominent feature of the tumour (*Figs.* 395, 398). The latter appearance was most frequent in tumours of the foot. A further notable feature is the relationship of the giant cells to the synovial spaces. While spaces do occur without related giant cells (*Figs.* 395, 396) it is common to find giant cells included among the cells lining them and projecting into the cavities (*Figs.* 398, 399), even where no giant cells are visible in the interstitial tissues (*Fig.* 398). Some of the spaces, particularly where they are large and numerous, are wholly or partially filled with foamy cells, often including foamy giant cells (*Fig.* 395). The lining cells frequently contain hæmosiderin also.

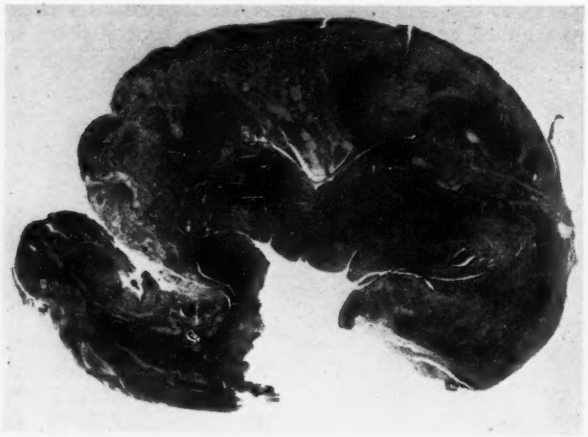

FIG. 400.—Low-power view of benign giant-cell synovioma which was situated over the extensor aspect of the proximal interphalangeal joint of the right middle finger. Note the synovial surface on the deep aspect of the tumour, with developmental synovial clefts above. (× 4·5.)

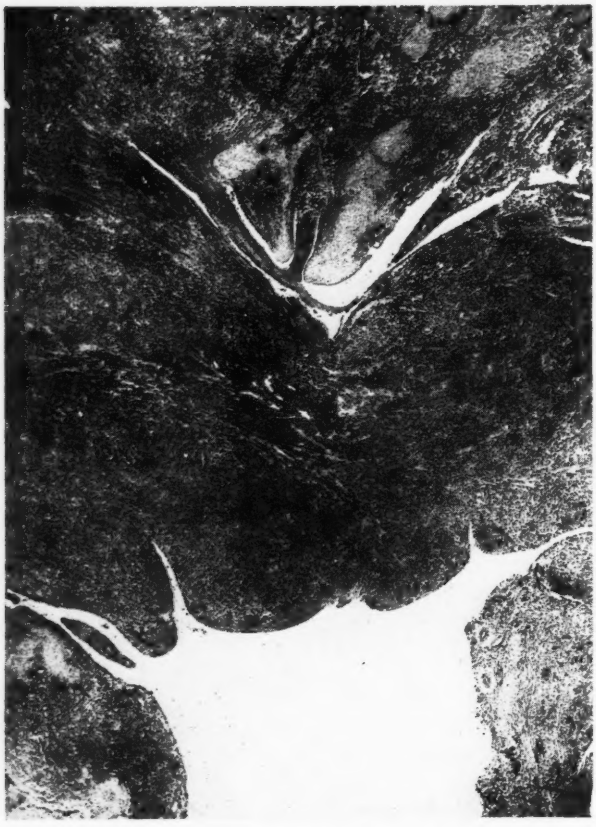

FIG. 401.—Higher-power view of part of *Fig.* 400, to show synovial surface and developmental synovial clefts. (× 17.)

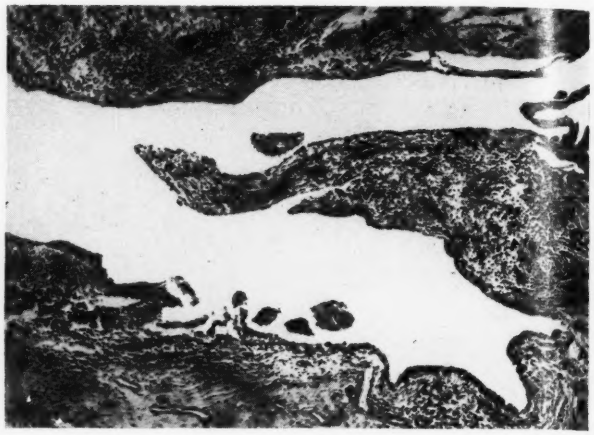

FIG. 402.—Section of para-articular benign giant-cell synovioma of the knee, showing papillary synovial tumour tissue in continuity with synovial membrane (below) which is infiltrated by lymphocytes, plasma cells, and histiocytes. (× 37·5.)

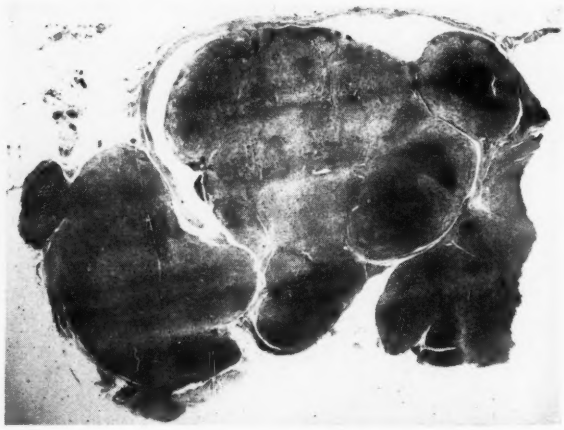

FIG. 403.—Low-power photomicrograph of benign giant-cell synovioma shown in *Figs.* 379, 380. The synovial sac where the tumour is in continuity with normal synovial membrane can be clearly seen in the upper part of the section. This sac communicated with the interphalangeal joint, which was thus opened during the excision of the tumour. Brown papillary tumour processes were noticed projecting from the tumour into the synovial pedicle. Note also the lobulation of the tumour and the fact that two nodules on the left are formed by herniation of tumour tissue through the capsule. (× 4.)

Histogenesis: Synovial Surfaces and Developmental Synovial Clefts.—The two most important microscopical features in favour of the benign giant-cell synovioma being of synovial origin are the synovial differentiation within the tumour substance and the fact that there is often a free tumour surface in intimate contact with a synovial cavity (*Figs.* 400, 401), whether of tendon-sheath,

joint, or bursa, and continuous with normal synovial membrane at its margins (*Figs.* 381, 387, 402, and 403). Utilizing a large series of cases, all stages in the development of these tumours from synovial membrane can be traced. The mechanism is quite obvious in tumours of the large joints such as the knee; it is in the common tendon-sheath and small joint variety that the mode of development is less readily visualized. Although the tumour is superficially encapsulated, this is often absent on the deep

FIG. 404.—Section of benign giant-cell synovioma to show three persistent developmental synovial clefts. The two situated below and to the right are partly obliterated. (× 20.)

aspect, where tumour tissue blends with synovial membrane (*Fig.* 387). One of the tendon-sheath cases in this series shows very strikingly the early stages of development (*Fig.* 391). The tumour commences as a villous structure arising from the synovial membrane and projecting into the synovial cavity of the tendon-sheath. As there is but little space within the sheath the tumour soon has to grow outwards and, owing to the original papillary structure, this outgrowth tends to assume the characteristic lobulated pattern with developmental synovial clefts running between the lobules (*Figs.* 400, 401). Additional lobulation may be produced by tumour tissue bursting through the capsule and continuing to grow outside it (*Fig.* 403). The developmental synovial clefts are quite different in size, shape, and position, from the differentiated spaces. They are usually lined by normal-looking synovial cells or synovial membrane and are long and narrow, almost linear (*Figs.* 401, 404). In the process of evolution these developmental clefts are usually obliterated and replaced by fibrous septa. At least 28 of the tumours in this series, excluding the 5 from the knee-joint, were found to have persistent synovial surfaces and developmental clefts in various stages, ranging from the early papillary synovial surface lesion to mere linear clefts (*Fig.* 404).

Changes towards Malignancy and the Relationship to Malignant Synovioma.—The group of tumours included in this study, while showing all gradations from the typical benign giant-cell synovioma (*Fig.* 394) to a more cellular variety of intermediate histological malignancy, are clearly all of the same class. No instance of the typical benign tumour having metastasized appears to have been recorded as yet, but the more cellular varieties do merge histologically with malignant synovioma

FIG. 405.—Section of benign giant-cell synovioma of the more cellular type, to show cellular area devoid of giant cells. This tumour recurred. (× 40.)

and its rare variant, malignant giant-cell synovioma. This latter tumour, which undoubtedly exists (e.g., Stewart's unpublished case, quoted by Willis, 1948) and is clearly the malignant counterpart of the benign giant-cell synovioma, infiltrates and even metastasizes. Cases are also recorded of malignant synovial tumours which show areas resembling the benign giant-cell synovioma (Berger, 1938; De Santo, Tennant, and Rosahn, 1941).

A case of benign giant-cell synovioma of intermediate histological malignancy and rapid recurrence has been described by the author (Wright, 1949). This variety is characterized by unusual proliferation of the polygonal synovial cells, which may become spindle-shaped. In the more malignant-looking examples the tumour shows extensive sheets of closely packed synovial cells, where mitotic figures may be abundant and giant cells relatively few (*Fig.* 405). Lipoid is still usually present, but in much smaller amount. Synovial spaces also are generally less numerous, but a variety, seen especially in the foot, and consequently often of large size, shows spaces which are both large and numerous and may indeed be the most striking feature of the growth (*see Fig.* 395). It will be seen, therefore, that as the more cellular tumours usually show fewer giant cells than the typical variety they will merge histologically with the malignant synovioma, either lepidic or hyalic elements predominating.

There were 27 tumours in this category, and a further 12 showed proliferation of the synovial cells, without any other deviation from the characteristic structure of the benign giant-cell synovioma. Siderosis was not confined to the more benign tumours.

An important feature of the whole group of benign synovial tumours is the encapsulation of the extrasynovial portions. Local infiltration is rare and slight. It was present in 5 cases, including 3 in which there was invasion of the overlying skin (*Figs.* 386, 406). Benign giant-cell synovioma of the foot tends to be somewhat more anaplastic and malignant looking histologically than the tumour as seen in other sites. It is still encapsulated, however, and in other respects conforms microscopically to the benign tumour.

Galloway and others (1940) stated that in their series of 70 cases (88 tumours) mitotic figures were only rarely seen and then in only 12 of the tumours. In the present series mitoses were found in at least half the cases and were very numerous in some of the more cellular examples (Wright, 1949).

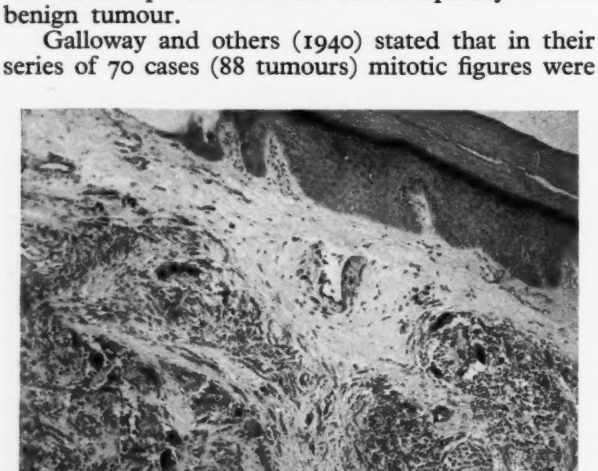

FIG. 406.—Invasion of the skin by benign giant-cell synovioma. (× 52·5.)

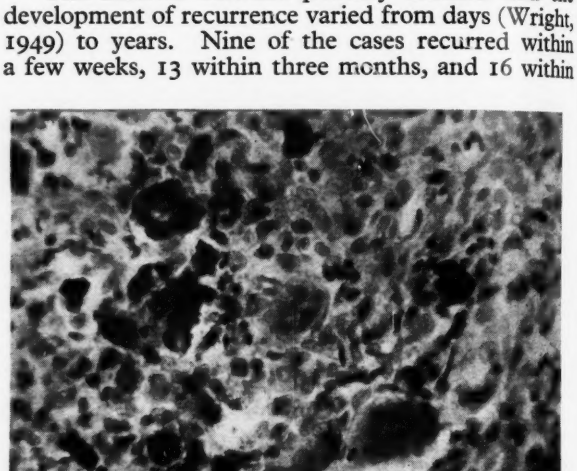

FIG. 407.—Focal calcification in a benign giant-cell synovioma. Note also the giant cells. (× 277·5.)

Focal calcification, not uncommon in malignant synovioma, was only encountered in one benign giant-cell synovioma (*Fig.* 407). This tumour, which arose from the flexor tendon-sheath of a finger, was of the more cellular type, with relatively few giant cells and was, in addition, cystic.

RECURRENCE

Recurrence in benign giant-cell synovioma is generally thought to be uncommon (Ewing, 1940; Charache, 1942; Willis, 1948). Ragins and Shively (1939) record 3 recurrences in 23 cases and Galloway and others (1940) 9 in 61 cases, while Foster (1947) mentions that 3 of his 42 cases were recurrences.

In the present series 56 cases have been followed up and the presence or absence of recurrence is known in 54, but in 2 of these recurrence was precluded by amputation being performed in the first instance. Recurrence was found to have occurred in 23 cases, or 44 per cent, and in 3 of these the tumour had recurred twice. In only 10 had the patient returned to hospital for further treatment; 15 patients were found to have recurrent tumours only after visiting them at their homes. The existence of this latter group may account for some of the discrepancy with the figures of previous authors. The patients are usually very sensitive about their recurrences as they are afraid of further operation; so much so that even when written to they may not mention the recurrence. Only 1 of the 15, subsequent to being visited, attended for further treatment.

A recurrence rate of 44 per cent is certainly high, even allowing that the rate for the cases not followed up would probably be rather less. It must also be taken into account that quite recent cases have been included.

The interval between primary excision and the development of recurrence varied from days (Wright, 1949) to years. Nine of the cases recurred within a few weeks, 13 within three months, and 16 within six months. The others recurred after 1 year, 1 6/12 years (2 cases), 2 6/12 years (2 cases), 4 years (2 cases), and 10 years.

In spite of this strong tendency to recur after excision, these tumours never seem to metastasize. Of the 56 patients followed up only 2 have died, in each case seven years after excision of the tumour. There was no evidence that the tumour was in any way related to their death. The 15 patients who still had recurrent tumours had had them for periods up to thirty-four years (Stewart and Wright, 1950). The freedom from metastasis is even more remarkable when it is considered that some of the tumours have been subjected to constant irritation owing to patients constantly massaging them or wrapping tight bandages around them at night in an effort to reduce their size. All the recurrences were of appreciable size and some quite large; that of thirty-four years' duration was 3 × 2½ × over 1 in., and the size of another of nine years' duration (*see Fig.* 374) may be gathered from the X-ray film (*see Fig.* 375). In this case the patient, a housewife, has repeatedly refused amputation as she is able to walk about quite easily with specially made shoes.

Recurrent tumours have been removed in 11 cases, 3 of them by amputation. One of the latter involved both flexor and extensor aspects of a finger (*see Fig.* 383). The remaining 8 were treated by further local excision, and in 3 of these a second recurrence developed shortly afterwards, one now involving both flexor and extensor aspects of a finger. Only 1 of the 3 cases has had further treatment and in this case amputation was performed a month after the

last local excision. A small recurrent growth was found at the site (*see Fig.* 391), illustrating the importance of removing the adjacent synovial membrane when excising these tumours. In this particular case, however, local excision would have been inadequate as the tumour proved to be multiple within the tendon synovial sheath (*see Fig.* 390). The other 5 are free from further recurrence after 5/12, 9/12, 1 4/12, 3, and 10 years.

Several factors have to be considered in the causation of recurrence in these tumours. Obviously in every case there must have been incomplete excision of the tumour in varying degree, but it is unlikely that this is the only determining factor. Histologically the tumours which recurred were usually of the more cellular variety—19 out of 22 in which histological sections were available.

Peripheral lobulation is a feature of many of these tumours and a tiny nodule of tumour tissue only loosely attached to the main tumour (*see Fig.* 376) might easily be left behind. In this case, however, the residual growth might be expected to grow only at the same rate as before, and it is unlikely that the recurrence would make its appearance as rapidly as has been found in many of the cases. More probably the incomplete excision resulted from the tumour being intimately blended with its deep structures of origin, whether of tendon-sheath or joint, and the cutting through of tumour tissue, with some relief of internal tension, might well stimulate the more cellular type of growth to more rapid proliferation. Indeed, when the recurrent tumours were compared with the originals, it was observed that in several instances the recurrence was, in fact, more cellular and showed distinctly greater mitotic activity (Wright, 1949).

All the cases of benign giant-cell synovioma of the knee-joint were treated by local excision of the tumour, and in 3 of the 4 which were followed up recurrence was found to have taken place.

The patient who had ten loose bodies removed from his knee remained well for ten years, when he again developed occasional swelling and locking of the joint. This state, which has gradually become worse, has now been present for four years, although it still does not greatly inconvenience him. On examination several loose bodies can be palpated in the joint. Another patient from whom the tumour shown in *Fig.* 393 was removed five years ago, still finds that the joint swells up very much at times and is unreliable when walking. In a further case where a semimembranosus bursa was excised, recurrence occurred three months later. The knee subsequently became swollen and 50 c.c. of blood-stained fluid was aspirated on three occasions. Exploration of the joint showed that the synovial surface was completely lined by brown frond-like structures. Portions were taken for histological examination together with a separate small pedunculated swelling the size of a pea, found in the inter-condyloid space. The patient was next seen eighteen months later complaining of recurrence of the swelling and pain in the knee of two weeks' duration. He had been training as a forester for the three months previously. Blood-stained fluid was aspirated from the joint and a further biopsy was taken. Following this, subtotal synovectomy was carried out, excluding the infracondylar area. Six months later there was no swelling and the patient was able to walk a mile. In the other case, where the tumour was apparently completely localized and had the form and size of a cherry attached by a long pedicle, there had been no recurrence after five years.

TREATMENT

Local excision is called for in benign giant-cell synovioma wherever anatomically possible. Unless, however, the local excision is reasonably wide and carried out with some knowledge of the nature of the tumour and its probable deep attachments, recurrence is by no means unlikely. Diagnosis should be possible at operation if not pre-operatively, although in fact the diagnosis is usually first made by the pathologist. It must be realized that the tumour is not always merely an encapsulated mass which can be easily shelled out, but that there are usually deep synovial attachments often formed of tumour tissue. The question of treatment usually arises after the tumour has been excised and the diagnosis made, as complete extirpation of the tumour may then be doubted. In these cases it is advisable to wait and see whether recurrence develops, unless there was obvious incomplete removal. All cases, especially those where the tumour is of the more cellular type, should certainly be followed up for at least six months, since the majority of recurrences develop within this period. If the tumour recurs, it should be excised in its early stages, as its development is likely to be progressive and amputation may eventually be necessary. As advocated by Stewart and Flint (1915), in the event of recurrence, whether the original tumour is of the more cellular type or not, a second local excision should be attempted unless the anatomical extent of the growth demands amputation.

COMMENT ON THE NATURE OF THE BENIGN GIANT-CELL SYNOVIOMA

As has already been stated, recent opinions are still varied as to the true nature of these growths, although it is now generally agreed that they are innocent. The three main hypotheses are that the lesion is inflammatory, that it arises as a result of disturbed cholesterol metabolism, or that it is neoplastic.

Jaffe and others (1941) thought that the growth represented an inflammatory response and was not a true tumour. The condition they described as villonodular synovitis is quite clearly the benign giant-cell synovioma in its villous form. The inflammatory hypothesis is untenable since the tumour in no way resembles granulation tissue, even in the papillary synovial surface lesions. None of the tumours examined in the present series showed any appreciable degree of infiltration by inflammatory cells, and certainly never more than is seen in any tumour as a result of irritation. If the lesion were inflammatory, the examination of tissues from a large number of cases of chronic synovitis and bursitis might be expected to reveal the early stages of the growth. Sections from nearly 200 routine biopsies in cases of chronic synovitis have been reviewed, but none has shown the slightest suggestion of synovioma. Benign giant-cell synovioma

may possibly, in rare instances, arise in a chronic synovitis; it is certainly not itself inflammatory in nature.

Galloway and others (1940) considered that the growth differed in its behaviour from simple inflammation and from neoplasia and probably developed in the presence of a coexisting disturbed cholesterol metabolism and secondary trauma or infection. The xanthic element in the benign giant-cell synovioma is such a very variable quantity that the growth can hardly be considered to be entirely a product of cholesterol imbalance. Moreover, apart from the xanthic areas the tumour is otherwise structurally quite different from the lesions of 'xanthomatosis', a condition sometimes associated with hypercholesterolæmia. In addition, it would seem that the benign giant-cell synovioma is never multiple, except in so far as there may be several nodules confined to one synovial sac.

Blood-cholesterol estimations have been carried out in 17 cases selected from the present series (*Table III*). These included recent cases, cases in which the tumour had been excised some years previously, and patients with recurrent tumours. The normal range of blood-cholesterol was given by Kaye (1940, 25 cases) as 154–273 mg./100 c.c. of serum, by Peters and Mann (1943, 312 estimations in 174 individuals) as 107–320 mg./100 c.c. of serum (average 202 mg.), and by Faber (1946, 73 cases) as 110–285 mg./100 c.c. (average 204 mg.). The average of the total 23 estimations carried out in the present series was 204 mg./100 c.c. plasma and in no case was hypercholesterolæmia found. Increased blood-cholesterol has been recorded by several investigators, including Galloway and others, but Jaffe and others have suggested that these cases may in fact be instances of xanthoma tuberosum multiplex. This is most probably true in some of the cases recorded by Galloway and others; their Cases 63–66 all had multiple tumours, in each instance involving more than one limb. Case 66, in which all four limbs were involved, had a blood-cholesterol of 476 mg. Estimations were carried out in 11 other cases; 2 were over 300 mg. (333 and 321 mg.) and 9 under 250 mg.

Table III.—Blood-cholesterol Estimations in 17 Selected Cases of Benign Giant-cell Synovioma

Case	Time Interval of Blood-cholesterol Estimation after Primary Excision of Tumour	Blood-cholesterol mg./100 c.c. Plasma
1	5 weeks (*before*)	260
	9 months	230
	1 year	210
2	1 week	220
3	1 week	210
	2 weeks	230
	4 weeks (recurrence present)	170
4	2 weeks	240
5	2 weeks	250
6	2 weeks	270
	2½ months	260
7	3 weeks	180
8	5 weeks (recurrence present)	170
9	1 6/12 years (recurrence excised 1 4/12 yr. ago)	140
10	2 10/12 years	180
11	3 10/12 years	140
12	4 2/12 years (recurrence excised 1 2/12 yr. ago)	200
13	4 3/12 years (recurrence present)	200
14	5 10/12 years	190
15	8 11/12 years (recurrence present)	180
16	12 10/12 years (second recurrence present, first recurrence excised 8 1/12 yr. ago)	180
17	38 years (recurrence of 34 years' duration present)	190
	38 1/12 years	180

As emphasized by Stewart (1948), the occurrence of cholesterol fat is often observed in tumours generally, either within the tumour cells or within non-neoplastic macrophages. Similarly the foamy-cell accumulation in benign giant-cell synovioma is a purely local phenomenon, in part related to the well-known phagocytic powers of the synovial cell. This cell is a differentiated histiocyte with specialized functions, but it still retains many of the more primitive functions of that cell, including the property of phagocyting cholesterol fat and hæmosiderin. It is therefore believed that the foamy-cell accumulations result from the phagocytosis of cholesterol fat produced by a slow necrobiosis of the tumour tissue, a process which is especially favoured by the long duration of some of the tumours and the trauma to which they are so often exposed. In the same way the siderosis of these tumours results from the breakdown of effused blood with phagocytosis of the iron-containing fraction. One of the more specialized functions of the synovial cell is the secretion or formation of mucinous fluid, the normal lubricant of joints and tendon-sheaths. This function seems to be in abeyance in the benign giant-cell synovioma, though present in some malignant synoviomas.

The benign giant-cell synovioma must certainly be regarded as neoplastic right from its early villous stage to its more cellular variant. The encapsulation, the differentiation into synovial-lined spaces within the tumour substance, the high recurrence rate, and the histological mergence with malignant synovioma are all in accord with this view.

SUMMARY

The digits of the hand prove to be much the commonest site of benign giant-cell synovioma. They occur on the extensor aspect as frequently as on the flexor, those on the extensor aspect probably arising from interphalangeal joint synovium. The average duration of the tumours at the time of the first consultation was 2 7/12 years and 40 per cent of the patients gave a history of injury.

Benign giant-cell synovioma always originates from synovial membrane and when arising from a tendon-sheath or small joint has a villous structure in its early stages. Eventually, owing to the lack of space in the synovial cavity, the tumour grows outwards as an encapsulated neoplasm. Encapsulation is often absent on the deep aspect, where the tumour blends with its synovial attachments. The villous structure often persists in varying degree as it always does when the joint space is large, as in the knee.

The most characteristic diagnostic feature of the tumour is not the giant cells but the differentiation into synovial-lined spaces within the tumour substance. Histologically the group includes all gradations from the typical benign form to a more cellular variety of intermediate malignancy, which in turn is closely related to the malignant synovioma.

Tumours of the benign type do not metastasize, but in this series recurred in 44 per cent of cases. Those which recurred were almost invariably of the more cellular variety. Incomplete excision of the synovial attachments of the tumour is probably the most important cause of recurrence. In addition, tiny lobules of tumour tissue only tenuously attached to the main mass may easily be left behind. Local excision is indicated in every case, whether primary or recurrent, provided this is anatomically possible.

The lesion is considered to be truly neoplastic. Blood-cholesterol investigations in 17 selected cases failed to reveal evidence of hypercholesterolæmia. The lipoid accumulations and the siderosis so commonly found in these tumours are considered to be of degenerative or traumatic origin or both, and purely local phenomena, in part related to the well-known phagocytic powers of the synovial cell.

I am deeply indebted to Professor M. J. Stewart for his interest and valuable advice during this investigation, which was undertaken at his suggestion and which includes many of his collected cases. I am also indebted to the honorary surgical staff of the Leeds General Infirmary for permission to make full use of their cases; to the honorary surgical staff and pathologists of a number of other hospitals for providing cases; and to Dr. W. N. Anderson, of the Department of Chemical Pathology, who has kindly carried out the blood-cholesterol estimations.

Since this work was completed, 2 of the more recent cases which had been followed up have now developed recurrence, bringing the total number of cases with recurrence to 25 (48 per cent).

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POSTERIOR MEDIASTINAL GOITRE

A REPORT OF THREE CASES

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RECORDED cases of goitre in the posterior mediastinum are so few as to justify the addition of a further three cases. The boundary between the superior and posterior mediastinal spaces is at the level of the lower border of the fourth thoracic vertebra (*Gray's Anatomy*, 1949, p. 1284). Prolongation of the goitre into the superior mediastinal compartment is well recognized; prolongation into the posterior mediastinum is less well known, and, in fact, goitre is not usually included in the list of tumours in this space.

Intrathoracic goitres were noted by Wakeley and Mulvany (1940) in 20 of a series of 1200 cases, 3 being totally intrathoracic, the remainder being partially so. In Crile's (1939) series of 11,800 thyroidectomies, 97 were intrathoracic. As for the incidence of posterior mediastinal goitre, it occurred twice in Urban's (1939) series of 8500 cases, and once in Henschen's (1940) series of 6000 cases. Three further cases were reported, by Bérard and Bérard (1935), von Haberer (1938), and Roholm (1938), although Roholm's case was not operated upon, the diagnosis being obtained from an aspiration biopsy from a tumour in the posterior mediastinum shown radiologically to be the size of a large fist. A seventh case was reported by Mora, Isaacs, Spencer, and Edidin (1944). The six cases described by Sweet (1949) provide the largest number reported by any single author; Linnell and Piercy (1949) state that, having dealt with many retrosternal prolongations of goitre, they found several extending into the posterior mediastinum. Recently, Keynes (1950) has described two intrathoracic goitres passing to the posterior mediastinum.

CASE REPORTS

Case 1.—A woman, aged 53, stated that a swelling in her neck had been noticed since childhood, and that goitre was a family complaint. Her maternal grandfather had a large goitre, her mother had an even larger one, and her sister had had a thyroidectomy performed several years before. In 1944 she had her chest X-rayed at a tuberculosis clinic, and was told then that the goitre was extending into her chest.

On admission to the Queen Elizabeth Hospital, in August, 1949, under the care of Dr. W. T. Cooke, her main complaint was that of difficulty and pain on swallowing, worse with solid food than with liquids, so that she had to cut up her food very finely, and to chew it for a long time. She pointed to the upper third of the sternum as being the site of the pain on swallowing. She

complained of a dry cough, but suffered no dyspnœa. Though she had lost 6 lb. in weight in the past twelve months, she had noticed no abnormal sweating, no palpitations, nor any unsteadiness of the hands. She had frequent attacks of sore throat, which quickly cleared up within 48 hours, and she had had pleurisy in 1940, 1944, and 1948.

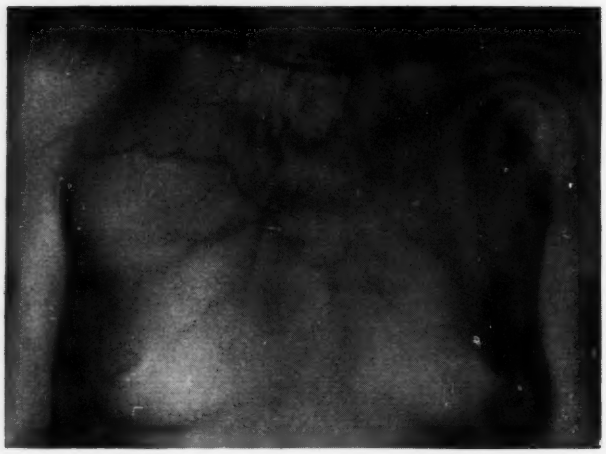

FIG. 408.—*Case* 1. Showing the distended chest veins, photographed by infra-red illumination on the fifth day after operation.

ON EXAMINATION.—There was no evidence of wasting, her weight was 7 st. 2 lb., and there were no signs of thyrotoxicosis. In the neck there was a prominent goitre, with distended veins over the upper part of the chest in front (*Fig.* 408). On palpation, there was a nodular enlargement of all parts of the thyroid gland. The right lobe was the larger, being about 5 cm. in diameter, and there was a swelling in the isthmus about 2·5 cm. across. Her pulse was regular at 72 per minute, and the blood-pressure was 110/85. The respiratory system was clinically normal, with expansion equal on both sides, percussion and auscultation being normal in all areas. On Aug. 31 the basal metabolic rate was + 11 per cent, with the pulse at 86 per minute. Previously, in May, 1947, the basal metabolic rate was recorded as being — 1 per cent.

FIG. 409.—*Case* 1. Radiograph showing the intrathoracic mass, anteroposterior view.

FIG. 410.—*Case* 1. Lateral radiograph showing a mass in the posterior mediastinum, lying behind the trachea and pushing it forwards.

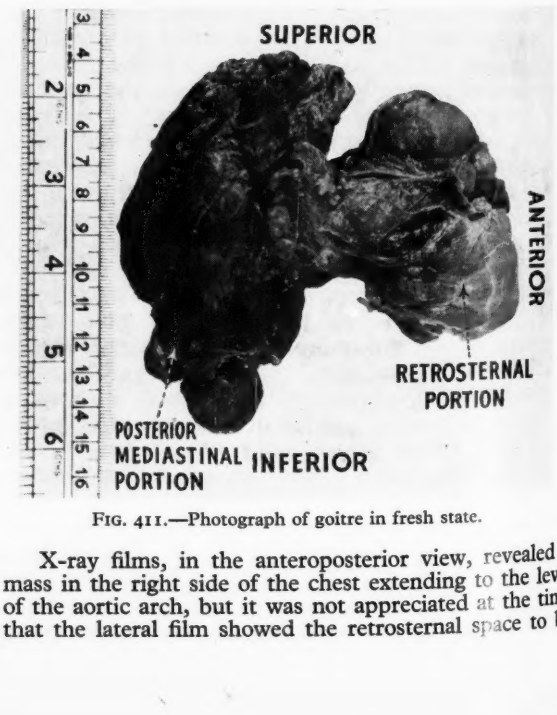

FIG. 411.—Photograph of goitre in fresh state.

X-ray films, in the anteroposterior view, revealed a mass in the right side of the chest extending to the level of the aortic arch, but it was not appreciated at the time that the lateral film showed the retrosternal space to be

clear, and that the mass lay behind the trachea, pushing it anteriorly (*Figs.* 409, 410).

AT OPERATION.—Assisted by Mr. B. N. Brooke, on Sept. 6, 1949, the gland was explored through a low collar incision, separating the muscles vertically in the midline. In an endeavour to deliver the thoracic part of the gland by the normal method of digital elevation, it was discovered that the main mass passed downwards and backwards into the paravertebral sulcus as far as the neck of the fith rib, and that only a small portion lay immediately behind the sternum. The posterior mediastinal prolongation was then delivered into the wound and the vessels ligated and divided. The whole of the right lobe and isthmus were excised and two-thirds of the left lobe. The right recurrent laryngeal nerve was then seen almost throughout its course. Since the blood-supply to the mediastinal prolongation came from above, there was no bleeding from the posterior mediastinal cavity after removal of the goitre. A rubber drainage tube was introduced into the cavity in the posterior mediastinum, and the wound closed in layers. The vocal cords were inspected by direct laryngoscopy after operation, and were seen to move normally.

Post-operative progress was satisfactory and uneventful, and she was discharged from hospital on Sept. 17.

THE SPECIMEN.—The pathological report stated: "A grossly enlarged gland weighing 220 g. Most of the acini show very marked colloid retention, and are lined by flattened epithelium. In many areas the acini are gathered into partly encapsulated nodules."

In the fresh state the gland weighed 255 g. The lobe consisted of two prolongations, the shorter one (7·0 cm.) lying behind the sternum, and the larger one (11·0 cm.) being the posterior mediastinal extension. The anteroposterior measurement was 11·0 cm. (*Fig.* 411).

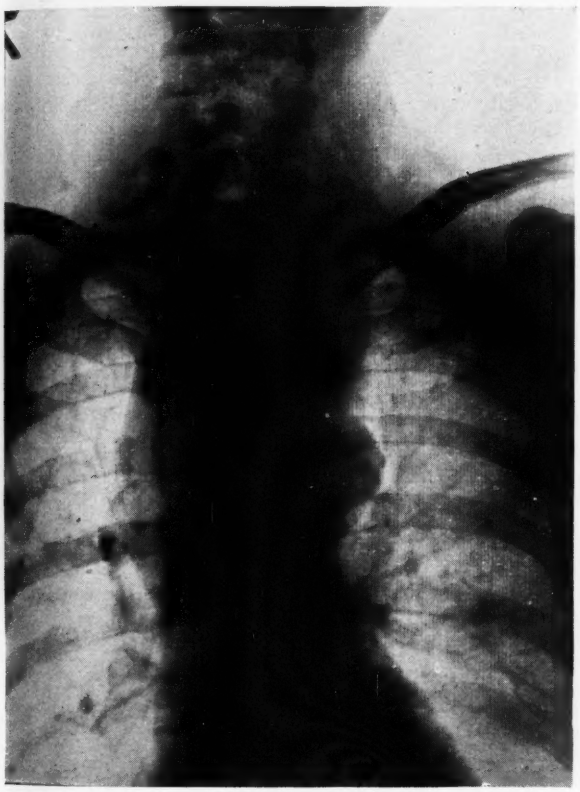

FIG. 412.—*Case* 2. Anteroposterior radiograph showing the intrathoracic tumour.

Case 2.—A man, aged 58, a printer by trade, who was admitted to the Queen Elizabeth Hospital under Dr. Brian Taylor on Feb. 2, 1947, stated that he had lost 2 st. in weight in three months and that trembling of the hands, particularly when writing, had been present for the same time. He had been aware of palpitations when at rest in bed, and he had a slight unproductive cough.

ON EXAMINATION.—He was a well-nourished man, and did not appear to have lost the amount of weight suggested. The thyroid gland was visibly enlarged, the right side being the larger. It was firm, without a thrill, and the lower margin could not be felt on swallowing.

FIG. 413.—*Case* 2. Lateral film, showing a mass in the posterior mediastinum pushing the trachea anteriorly.

The basal metabolic rate on Feb. 13 was + 40 per cent and the pulse-rate 107 per minute, showing some degree of toxicity. Radiological examination of the upper chest on Feb. 13 showed on the anteroposterior film a swelling in the chest extending to the 6th rib posteriorly, but it was not noticed that the lateral film demonstrated that the trachea was not displaced posteriorly, and that in fact, the tumour lay behind it (*Figs.* 412–414).

AT OPERATION.—Mr. A. L. d'Abreu operated upon this patient on Feb. 25 under general anæsthesia. A collar incision was made, and an adenomatous right lobe of the thyroid removed. Exploration of the left lobe revealed a large extension into the posterior mediastinum, passing behind the trachea, and terminating close to the auricle. It was about 12·5 cm. long, and was removed.

The basal metabolic rate on March 11 was + 10 per cent, and he was discharged with the wound completely healed on March 25. Radiological examination on June 2, 1947, showed the lung fields clear and no tracheal compression.

THE SPECIMEN.—The pathological report stated: "This has the main structure of a colloid goitre, but there are foci of hyperplasia with evidence of colloid absorption suggesting thyrotoxic changes."

Case 3.—A housewife, aged 35, who was seen by Dr. Brian Taylor at his out-patient clinic at the General Hospital, Birmingham, on June 10, 1947, and was subsequently admitted to the Queen Elizabeth Hospital on Jan. 1, 1948, under Mr. A. L. d'Abreu.

FIG. 414.—*Case* 2. Lateral film, showing, with the arms raised, more clearly than *Fig.* 413 the position of the tumour and the forward displacement of the trachea.

She gave a history of dyspnœa of two years' duration. Three years previously she had been in a sanatorium for some months with a diagnosis of pulmonary tuberculosis; an effusion had been aspirated three times. Since then she had been getting breathless easily, but had no cough or sputum. X-ray examination of the chest seven months before revealed a shadow in the upper right mediastinum which was thought to be a dermoid cyst.

ON EXAMINATION.—She was a pale woman of medium build. The right side of the chest was observed to be moving less than the left side, but no displacement of the mediastinum was detected. Unfortunately, there is no record of the clinical condition of the thyroid gland in the neck.

Radiological examination of the chest on Jan. 6, 1948, was reported as follows: "The upper mediastinal mass is predominantly to the right of the trachea as well as behind it. An area of calcification is shown, conforming to no particular pattern (e.g., teeth). The trachea is pushed forwards and to the left." (*Figs.* 415, 416.)

The basal metabolic rate was not estimated, since the thyroid was not considered to be the source of the tumour.

AT OPERATION.—On Jan. 13, Mr. d'Abreu exposed the mediastinal mass, under general anæsthesia, through a right thoracotomy incision, resecting the 5th rib subperiosteally. The pleura was opened. Over the tumour, superomedially, vascular adhesions were present, and when freed from these the lung collapsed into the lower chest. The tumour was then identified as a mediastinal thyroid gland, about 6·25 cm. in diameter. It was lying in the paravertebral sulcus, extending up to the apex of the thoracic cage. Seen from the side, the superior vena cava lay immediately in front, while the subclavian artery ran over the top of the tumour. The fibrous capsule was incised, and the thyroid freed by blunt dissection. The pedicle lay superiorly, and passed medially and upwards into the angle between the superior vena cava and the subclavian artery; it was ligated with thread and divided. The wound was closed without drainage.

She was sent to a convalescent home in February, 1948. When seen again in November, 1948, she was well and symptomless.

THE SPECIMEN.—The pathological report stated: "This tissue has the structure of a thyroid adenoma."

DISCUSSION

The approach to posterior mediastinal goitre has been through a cervical incision in the majority of cases reported, and this was used in *Cases* 1 and 2 of this paper; the ease with which these were enucleated once it was realized that the extension lay in the posterior mediastinum and not in the more usual retrosternal position, recalls Lahey's (1931) statement: "The most certain way of delivering an intrathoracic goitre is that of inserting a finger into the mediastinum, sweeping the finger about the tumour in order to free it from the condensed layer of connective tissue which surrounds it, and to pry the growth out by pressure from below upward."

A thoracotomy approach was used in three of Sweet's (1949) cases, and in *Case* 3 of this report it

FIG. 415.—*Case* 3. Anteroposterior film, showing the intrathoracic goitre.

was employed because there was no pre-operative suggestion that the swelling arose from the thyroid. The objection to using the thoracic approach lies in the difficulty in securing the blood-supply, and this was encountered in our case. Keynes (1950)

in his two cases carried out mediastinotomy by splitting the sternum to the third intercostal space, and he gave it as his opinion that it would have been impossible to remove the tumours without this extra freedom. The second case of posterior mediastinal goitre to be reported, that of von Haberer (1938), was removed by splitting the sternum, and this was also done in Linnell and Piercy's (1949) case.

FIG. 416.—*Case* 3. Right anterior oblique radiograph, showing a tumour in the posterior mediastinal compartment with forward displacement of the trachea.

Hollenberg (1946) stated that, in general, intrathoracic goitres should be removed from above, but that an approach through the chest could be used for very low-lying goitres in the region of the diaphragm, and for malignant degeneration of an intrathoracic goitre, but that if there is an extensive enlargement of thyroid tissue in the neck, and, likewise, a large portion in the chest, it would no doubt be better to remove the portion from the neck at a first stage, separating it from the intrathoracic gland, and at a second stage to remove the intrathoracic portion transpleurally.

The usual thoracic extension of a goitre is into the superior mediastinum, and it is the lower pole which so descends. In several of the posterior mediastinal goitres, the presence of a pedicle connecting the cervical and intrathoracic portions has been observed, and such a pedicle was present in each of the three cases now described. It would appear that the presence of the enlarged lower pole of the goitre lying in the retrosternal position pushes the extension of the posterolateral part of the gland into the posterior mediastinum, where it may descend relatively unhindered. As it descends, it passes posterior to the recurrent laryngeal nerve, inferior thyroid artery, and carotid sheath. Descent anterior to the recurrent laryngeal nerve and inferior thyroid artery characterizes the retrosternal type of prolongation.

The X-ray appearances are characteristic and must be appreciated if a correct diagnosis is to be made. In the anteroposterior film the thoracic extension of the goitre is seen (*Figs.* 409, 412, 415), but there is nothing significant to suggest the posterior position. This is shown in the lateral film, for the tumour lies behind the trachea, usually pushing it anteriorly, and there is no swelling in front of the trachea compressing it. (*Figs.* 410, 413, 416.) In two of the three cases reported here it was known that the tumour arose from the thyroid, but their posterior position was not recognized despite the X-ray appearances. In the other case the posterior position was recognized from the X-ray photograph, but the nature of the swelling was mistaken. In order to enucleate a goitre through the neck it is necessary to realize the posterior extension, since an attempt to deliver the mass as a simple retrosternal prolongation might result in tearing across the connexion between the retrosternal and posterior mediastinal prolongations (*Fig.* 411).

It is of interest that in two of the cases the patients had been radiographed because of suspected tuberculosis, and that the shadows of the thyroid mass were first noticed on these examinations.

SUMMARY

1. The previously reported cases of posterior mediastinal goitre are mentioned, and their relative rarity indicated.

2. Three further cases are described.

3. The nature or site of the swelling has not always been appreciated before operation, despite the X-ray evidence.

4. Removal by a cervical incision is usually possible, and is an advantage as the blood-supply is from above; the vessels and the recurrent laryngeal nerve lie behind a retrosternal prolongation, but in front of an extension into the posterior mediastinum.

I wish to thank Mr. A. L. d'Abreu for allowing me to report the cases operated upon by him; Professor F. A. R. Stammers and Mr. B. N. Brooke for their valuable help in the preparation of this paper; Miss B. M. Randell for her secretarial assistance; and Mr. F. Dee for the photographs of the specimen and X-ray films.

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HERNIAL REPAIR BY WHOLE-SKIN GRAFT
WITH REPORT ON 413 CASES

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THE presence in the corium of the skin of an easily accessible source of fibrous tissue, has led to the investigation of its use in the repair of tissue defects. It has, however, one outstanding disadvantage—namely, that the epithelial elements, penetrating to the base of and often through the corium, cannot be wholly removed mechanically. Thus, on the ability of the body to remove these epithelial elements depends the practicability of the use of the corium for such purposes as the repair of herniæ, for otherwise the implanted epithelium will result in cyst formation.

Two distinct points of technique have been emphasized as important in facilitating the disappearance of the epithelium of the implanted graft—namely, the partial removal from the graft of the epithelium mechanically; and secondly, the securing of the graft under tension.

Most workers (Uihlein, 1939; Cannady, 1942; Swenson and Harkins, 1943; and others) using skin experimentally and clinically have followed Loewe (1913) in attempting to remove as much epithelium as practicable from the graft. Harkins (1945) reviews the various methods by which this may be done and shows how accurately the epidermis may be removed with a dermatome. This, however, leaves the epithelium of the sweat and sebaceous glands and hair follicles, and any attempt to reduce this merely results in a thinner corium. (Such a graft is conveniently called 'dermal' or 'cutis' as distinct from 'whole skin'.)

Mair (1945, a, b) considered that disappearance of the epithelium is best secured not by a quantitive reduction in the amount of epithelium, but is dependent on the manner in which the graft is implanted. In a comprehensive review of the experimental work both with dermal and whole-skin grafts he suggests that the deciding factor is the fixation of the graft under tension.

Experimentally, Mair, working with rabbits, found that from a whole-skin graft stitched under tension to a defect in the lumbodorsal fascia, the epithelium was rapidly removed; whereas Zimches (1931) had found that strips of whole-thickness skin buried in muscles of dogs folded into a U shape and a cyst or cysts were formed. Harkins (1945) reported on the use of cutis, from which the epidermis had been removed with great care with a dermatome. This he implanted in various manners and at different sites in dogs and observed "pus, hair, sebaceous material, or sinuses in 18 of 24 experiments", but noted "no gross complications of healing in six experiments where the graft was actually sutured under tension", though only one of the latter examined histologically showed the absence of epithelial elements.

Clinically, the main purpose for which the use of corium has been tried is hernial repair, but Cannady (1942) suggests that it (as cutis) "may be used in all cases in which the use of fascia or tendon might be indicated with the expectation of superior results". He reports the use of such a graft in 37 cases. Uihlein (1939) used cutis "devoid of epithelial covering" in 104 cases. He also emphasized clean dissection, hæmostasis, and the securing of the graft under tension as important to securing a good result. Harkins (1945) reported 11 herniæ so treated. Goodall and Guthrie (1947), 6 cases.

Removal of the epidermis is a step which Mair considers unnecessary. He has reported a series of 149 inguinal herniæ treated by the whole-skin method and states that the risk of inclusion cyst formation has not been significant. Marsden (1948) reports 163 cases of inguinal herniæ in which the same method was used and reported no cyst formation. Other short series have been reported, including West and Hicks (1948), 25 cases, and Pataro and Zavaleta (1947), 23 cases.

It would appear that most workers, whether using dermal or whole-skin grafts, have not encountered cyst formation as a significant complication.

The purpose of this communication is to report the results observed in the follow-up of 413 herniæ treated by the whole-skin method. Without any attempt to remove the epidermis, whole-thickness skin was used as a reparative material, relying only on its suture under tension to secure the desired incorporation of the corium and complete removal of the embedded epithelial structures. In assessing the value of this method, the main inquiry has been in two channels: First, the occurrence of the specific complications to be anticipated from the use of the material—namely cysts due to persistent epithelium and sepsis from organisms implanted with the graft; Secondly, the recurrence rate, which should afford some indication of the efficiency of the method.

At a recent follow-up it was possible to examine personally all but 90 of the results of the 413 operations reported. Of the 369 patients only 20 have not reported for any follow-up. The operations were carried out on two surgical units by consulting surgeons and registrars, but the great majority (137 and 152) were performed by two surgeons.

TYPES OF HERNIÆ TREATED

Inguinal	Indirect	254	370	413
	Direct	116		
	(26 Saddle bag)			
Femoral			25	
Umbilical			6	
Incisional			12	
Recurrent	Inguinal		25	29
	Femoral		3	
	Incisional		1	
Strangulated	Inguinal		10	17
	Femoral		5	
	Umbilical		2	
Multiple	Bilateral inguinal		40	44
	Bilateral femoral		2	
	Inguinal and incisional		1	
	Repeated skin repair		1	

In all these cases the same basic technique was used, with the exception of some inevitable minor differences. Where some form of repair was indicated then the case was with few exceptions considered suitable for the skin-graft method. An unhealthy state of poor quality of skin was considered a contra-indication. This technique was seldom used for strangulated herniæ for several reasons, principally fear of infection from inadequate preparation of the skin, the prolongation of the operation in the presence of obstruction, and the possibility of infection from strangulated bowel. The method was not employed if bowel had to be resected. Few cases of umbilical or incisional hernia were treated by this method mainly because the early results in the latter type of herniæ were unsatisfactory.

Old age was not considered a contra-indication. The average age was 48 years; 73 cases were over 60, and of these 16 were over 70 years old. In fact, the elderly manifested remarkably few of the possible complications.

Where more than one hernia was present both were usually treated by skin repair at the same operation. In 6 instances, however, the associated hernia was treated by some other method.

The following are relevant data concerning the cases:—

Age: Average age for 369 patients—48 years.	
Strain: History of strain associated with the onset of inguinal herniæ	147
Chronic cough	59
Truss: Inguinal 73; Femoral 2.	75
Work: Moderate manual labour.	164
Heavy " "	62
Duration: Herniæ present over 5 years	85

OPERATIVE TECHNIQUE

Skin Preparation.—Preparation on two consecutive days before operation, as described by Mair, was carried out for the first 100 or so cases. Thereafter routine preparation was reverted to, i.e., the patient was admitted to hospital on the day prior to operation and given an evening and morning skin preparation. No significant alteration in the occurrence of sepsis was noted in consequence.

Anæsthesia.—For the majority of the earlier cases (121) spinal anæsthesia was used, whereas a light general anæsthetic with curare was administered for the more recent group (249).

Procedure.—The sac was dealt with in the usual manner. Orchidectomy was carried out in 13 cases—all elderly patients—in 5 instances for associated hydrocele or spermatocele, but in the remainder on account of the large size of the hernia.

Skin for the graft was in most instances taken from over the site of the hernia, but in some cases, where this skin was poor or the site of a scar from previous operation, the incision was extended laterally to enclose an ellipse of skin with tougher corium. After trimming, the graft was sutured in position under tension with fine (3/0 or 2/0) chromic catgut sutures placed at ¼-in. intervals. The manner of placing the graft differed from that described by Mair (for inguinal herniæ) in that the lateral part of the graft was not split to enclose the cord. The lower margin of the graft was sutured to the inguinal ligament both medial and lateral to the cord, so that the cord passed under an arch rather than through a hole in the skin-graft. This was done because it was technically easier and avoided suturing graft to graft.

In the case of femoral herniæ the lower medial margin of the graft was sutured to Poupart's ligament usually with stronger gut or thread; a similar procedure was carried out for those cases of inguinal hernia where an associated femoral weakness was found.

Umbilical herniæ were repaired by the Mayo technique, and in the case of incisional hernia the edges of the defect were sutured together in layers; then in both types the graft was placed under tension as a patch over the line of suture.

Penicillin powder locally was not used as a routine, but was applied in strangulated herniæ. Systemic penicillin was given routinely by one surgeon in 29 cases and in cases of strangulated hernia and for post-operative pyrexia.

Post-operative Régime.—Patients were kept strictly in bed for three weeks after operation. This period appears necessary both on account of the considerable reaction noted in most cases up to well over two weeks and as an early strain would be liable to separate the graft from the inguinal ligament—sutured as it is with fine catgut—before firm fibrous tissue has been laid down. This is a definite disadvantage in the method of repair as compared with the brief period in bed required when such materials as floss silk (Maingot, 1948) or stainless steel wire (Abel and Hunt, 1948) are used. It is of interest to note in this connexion that Shelley (1940, a, b), investigating the results of several methods, found a recurrence rate 55·5 per cent higher for those kept in bed less than 15 days as compared with those kept in bed longer.

POST-OPERATIVE COMPLICATIONS

SUMMARY

	No.	*Percentage*
Sepsis	18	4·3
Recurrence inguinal hernia	25	6·8
Non-absorption epithelium proved	9	2·2
" " suspected	6	1·5
(The above significant complications are discussed below.)		
Pyrexia: Over 100° F. for over 4 days	58	14·8
Hæmatoma (3 with testicular operation)*	8	1·9
Chest, i.e., more than mild bronchitis	21	5·1
Pulmonary embolism—not fatal	1	0·3
Discomfort (persistent and without obvious cause):		
Inguinal	4	1·1
Femoral	2	8·0
Thickening, persistent:		
Inguinal	3	0·8
Femoral	1	4·0
Hydrocele	3	0·8
Varicocele	1	0·2
Testicular atrophy†	4	1·1
Death (perinephric abscess) discussed under sepsis	1	0·3

* Two cases of hydrocele and one spermatocele removed at same operation.

† One had spermatocele removed at the same operation.

Sepsis.—

ANALYSIS OF POST-OPERATIVE SEPSIS

	No.	*Percentage*
Inguinal herniæ	16	4·3
Incisional herniæ	2	16·7
Total	18	4·3
Strangulated herniæ	0	
Sepsis under 3 months	10	
Sepsis persisting over 3 months	8	
Metastatic infection (doubtful)	2	

Frank sepsis, that is a purulent discharge from the wound, occurred in 18 cases (4·3 per cent).

In inguinal herniæ 4·3 per cent sepsis is similar to Mair's findings (3·3 per cent) and Marsden's 6·1 per cent for skin repair, and does not differ very significantly from the sepsis rate found using other methods of repair, e.g., Shelley (1940, a, b) found 3·5 per cent sepsis in 1668 cases of indirect hernia, while others note as low as 1 per cent sepsis.

Of outstanding significance is the fact that in 8 of our cases sepsis went on for over three months. Since a chronic sinus following repair with some foreign material usually indicates the failure of incorporation of that material and may necessitate its removal, so it was found on exploration of 3 of the 5 cases of persistent sinus that unabsorbed epithelium was present. Bearing in mind that even with the most careful skin preparation it is doubtful whether full sterilization of the skin was ever secured, it is therefore surprising that sepsis was not more frequently seen. As already noted, no increase in the occurrence of sepsis was found on reducing the skin preparation from two days to one day prior to operation, and though fear of sepsis was the main reason why so few strangulated herniæ were thus treated, yet of these 17 cases none developed sepsis.

As Mair and others have shown experimentally, the presence of the graft invokes an intense inflammatory reaction and the graft bed becomes lined by granulation tissue. This reaction would appear to be mainly concerned in the removal of the epithelium and incorporation of the collagen of the corium in fibrous tissue, but evidently is capable in most cases of dealing with such organisms as may be introduced with the skin. Mair notes that within four weeks " many specimens, as might be expected, have shown microscopic abscess formation, which contained clusters of staphylococci ". Should this inflammatory reaction fail to deal with organisms in the implanted graft, then local sepsis or metastatic infection may occur.

Local sepsis, though mostly mild, was in 2 cases severe and was in these cases associated with the destruction of the whole graft.

The possibility of metastatic infection is perhaps substantiated by two cases :—

1. A. M., aged 34. Re-repair of recurred right inguinal hernia. On the seventeenth day wound was inflamed and patient developed a crop of boils on face and upper thighs. With a course of sulphathiazole the boils cleared up and the wound ceased discharging after two weeks. Recurrence of hernia four months later. Patient states he cannot recall ever having boils before or since.

2. R. C., aged 72. One month after prostatectomy admitted as a strangulated right inguinal hernia. A large scrotal hernia was reduced by taxis. Patient insisted on operation, which was done three days later. A rigor occurred two weeks after operation and there was local inflammation, but no discharge. In spite of localization and drainage of a large perinephric abscess, patient died.

The significance of the latter case is doubtful in view of the recent operation of prostatectomy. This was the only death in the series.

Recurrence.—In assessing results we have used the same criteria as Mair in that " any case which presented a bulge over the operation area was considered to be a recurrence. If there were any doubts it was listed as failure ". Two cases of ' bulge ' were, however, considered to be due to cyst formation and not recurrence. Of the 29 recurrences noted, 12 were classified as weakness or slight bulge on clinical examination.

Certain factors were investigated with a view to their possible relationship to the recurrence rate.

Hernia	*No. Operations*	*No. Recurrences*	*Percentage Recurrences*
Indirect inguinal	254	8	3·2
Direct inguinal	116	17	14·7
Recurent inguinal	25	6	24
Total inguinal	370	25	6·8
Femoral	25	1	4
Umbilical	6	0	0
Incisional	12	3	25

1. *Type of Hernia.*—The figures indicate the expected relation between the recurrence rate and the extent of the defect repaired. The results are least impressive in just those cases where a substantial repair was required and it was hoped the method would be of most value. Marsden (1948) reports very similar results : simple oblique 4 per cent ; recurrent oblique 8·6 per cent ; simple direct 4·3 per cent ; recurrent direct 23·7 per cent.

2. *Recurrence Rate for Inguinal Herniæ in relation to Age.*—The figures given are interesting in that the recurrence rate does not increase with age in the clear-cut manner found by some writers (Shelley, 1940, a, b).

Age	20–39	40–59	60 and over
Operations	92	202	76
Recurrences	9	9	7
Percentage recurrence	9·8	4·5	9·2

Several factors may be considered as having a bearing in the production of the high proportion of recurrences in the younger age groups :—

a. The 92 cases between 20 and 39 are only a fraction of the total cases in this group operated on, a simpler form of repair being considered sufficient in the other cases. The figure is therefore not the true recurrence rate for total inguinal herniæ in this group.

b. Most patients in the younger age group return to their former employment, whereas many in the middle age group return to a lighter job. In fact, the physical stress and strain factor is greater in the younger decades of life.

c. As far as the writer knows, there is no definite clinical or experimental evidence to indicate in the various age groups a difference in the toughness of the fibrous repair resulting from the skin implant.

3. *Surgeon.*—The recurrence rate was almost identical for the two surgeons doing the bulk of the cases.

4. *Cough.*—Chronic cough or post-operative chest complications was twice as frequent among the cases which recurred as in the total cases operated on (33 per cent and 16 per cent).

5. *Anæsthetic.*—Recurrences in these cases receiving a spinal anæsthetic were twice as common as in those where general anæsthesia was used, but as all the earlier cases received spinal anæsthetic and these were followed up over a longer period, this is probably not significant.

6. *Sepsis.*—Post-operative sepsis was over twice as common in cases of recurrence as sepsis in the whole series (11·1 per cent and 4·3 per cent).

7. *Cyst Formation.*—In 3 cases of recurrence, cysts due to unabsorbed epithelium were found, but

as only 7 recurrences have been subjected to re-operation it is difficult to say how frequent is the association of cysts and recurrence.

Time of Recurrence in Inguinal Hernia.—A disconcertingly high proportion of the recurrences were found in the third year after operation. However,

TIME OF RECURRENCES IN INGUINAL HERNIA

	Time after Operation			
	Under 6 m.	6 m.–1 yr.	1–2 yr.	2–3 yr.
Operations	370	290	217	74
Recurrences	6	6	7	6
Percentage recurrences	1·8	2·1	3·2	8·1

this may partly be due to the fact that the early follow-up of these cases was carried out by others with perhaps less exacting criteria of cure. On the other hand, it is possible that since the repair depends for its reinforcement on the stretchable corium and

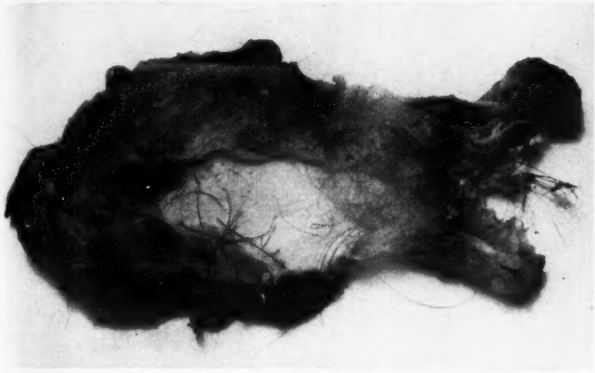

FIG. 417.—*Case* 2. Photograph of part of tissue removed from inguinal canal 27 months after skin repair for inguinal hernia. The epithelium which partly lined the cyst is clearly seen.

the new fibrous tissue laid down around it, recurrence will tend to occur gradually. The figures certainly suggest that a short follow-up of say a year will give an inaccurate idea of the recurrence rate.

COMPARISON WITH OTHER SERIES OF RECURRENCE RATE IN INGUINAL HERNIÆ

Method	*No. in Series*	*Percentage Recurrence*	*Author*
Skin repair	163	9·6	Marsden
Skin repair	149	under 1	Mair
Skin repair	370	6·8	Present series
McVay	367	under 1	Harkins and Shug
Steel wire	376	under 2	Pratt
Floss silk	over 1000	3	Maingot
Various	2902	8·8	Shelley

Only a few series are compared, for, as Aird points out, the incidence of recurrence after a Bassini type of operation for indirect hernia varies from 3 to 20 per cent, while the recurrence rate in direct herniæ is reported variously to be between 7·8 and 29·1 per cent. This suggests that such a comparison is of little value.

However, a comparison of these results with a similar series treated by another method, but by the same surgeons, would be more informative. It is hoped to do this on another occasion.

Non-absorption of Epithelium.—Cyst or chronic sinus formation was found at operation in 9 cases to be associated with persistent epithelial elements of the implanted graft. A brief summary of the clinical and pathological findings of these cases is given.

1. P. C., aged 62. July, 1946, skin repair for large bilateral indirect inguinal hernia. Left hydrocele present but not treated then. No post-operative complications. October, 1947, orchidectomy for left hydrocele. Though no weakness was detected, the site of the graft was explored from interest, and three cysts containing sebaceous material and hairs up to 1 in. long were removed.

FIG. 418.—*Case* 2. Photomicrograph of posterior wall of cyst at margin of original graft. Hair follicles and sweat and sebaceous glands of the dermis of the graft can be clearly distinguished. (× 30.)

Histological examination of this material showed two distinct zones: (*a*) a surface layer composed of vascular and cellular granulation tissue containing giant cells and, deeper, a few residual sweat-glands; (*b*) cyst lining which in places approximates to normal epidermis, but which elsewhere is thin and flattened. The epidermis ends abruptly in granulation tissue, in which there are occasional islands of degenerate epithelial cells. In one area there is a direct continuity of epithelium between two cysts. In the true dermis, sweat and sebaceous glands and hair follicles are seen.

The cyst material, which was not examined bacteriologically, contains fat globules and desquamated epithelial cells. February, 1949: Both groins sound.

2. J. S., aged 33. February, 1947, skip repair for moderately-sized right, indirect, inguinal hernia. Post-operative pyrexia 99° to 101° for four days. Direct bulge lower end scar noted 19 months later. At further operation, May, 1949, indirect sac 5 in. long removed. Sausage-like cyst found at site of former graft. This was not attached to inguinal ligament at any point. The cyst was excised and repair with stainless steel wire carried out.

The cyst (6·5 × 3 cm.) contained hair and sebaceous material. Only 2·5 × 1·5 cm. of lining consisted of skin, but hairs appeared to be growing from this and the remaining fibrous wall.

Histology: (*a*) Area covered by intact epidermis with flattened interpapillary processes: in places stratum corneum is absent—the most superficial layer being degenerate stratum granulosum; elsewhere all the layers are present. Hair follicles and sweat and sebaceous glands are present in the dermis, which also shows round-cell perivascular infiltration. (*b*) Other fields show a surface layer consisting of vascular granulation tissue

FIG. 419.—*Case* 3. Photograph of cyst removed two years after skin repair of inguinal hernia. Specimen is 9 cm. × 3 cm. and up to 5 mm. thick.

containing plasma cells, polymorphonuclears, and multinucleated giant cells of the foreign-body type. The deeper layers in places show hair follicles (some showing hyaline change) and sweat and sebaceous glands.

Culture: Profuse growths of saprophytic staphylococci.

3. E. R., aged 36. July, 1947, skin-graft repair for right indirect inguinal hernia of four years' standing. Uneventful convalescence. Weakness and thickening

FIG. 420.—*Case* 3. Photomicrograph of part of wall of cyst. The lining of the cyst consists of a deep layer of granulation tissue in which remnants of degenerate epithelium and occasional sweat-gland and hair follicle can be found with difficulty. (×25.)

noted at follow-up 18 months later. Had second operation in June, 1949; canal was re-explored and a large cyst (9 cm. × 3 cm.) was dissected from site of skin repair. Its lower margin lay along the inguinal ligament and its posterior surface was firmly attached.

The wall of the cyst was thick—up to 5 mm., in places. Its lining was most uneven and appeared to consist of fibrous tissue and no evidence of epidermis could be seen on naked-eye examination. It contained sebaceous material and hair. Scattered hairs were noted growing from the whole cyst lining.

Histology: In most areas epidermis was completely absent, the surface layer consisting of vascular and cellular granulation tissue. There were, however, small areas of degenerated epithelium and an occasional sweat-gland and hair follicle.

In the cyst lumen there were numerous pus cells; no organisms were seen and the cultures were sterile.

4. J. M., aged 55. April, 1947, operation for strangulated right indirect inguinal hernia. Gut viable, skin-graft repair. Uneventful convalescence. Recurrence direct hernia—noted three months later.

At second operation, April, 1948, right direct inguinal hernia found. Cyst, 3 × 1 in., containing white soft sebaceous material and hairs found at site of skin implant. Cyst was excised and a further skin repair carried out.

Unfortunately cyst was not kept for histological examination. A year later scar was sound.

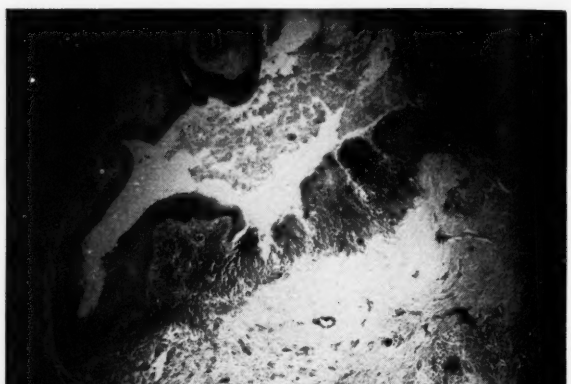

FIG. 421.—*Case* 5. Photomicrograph of cyst at margin of area corresponding to original graft, which is seen in lower part. Part of the epithelial lining has been replaced by granulation tissue, while the opposing wall is lined by new epithelium. Epithelial structures can be seen in corium in the lower part of the plate. (× 8·5.)

5. G. S., aged 40. September, 1947, skin-graft repair for moderate, left, indirect, inguinal hernia. Post-operative collapse lower lobe left lung. Not free from cough till six months after operation.

As patient complained of increasing discomfort and swelling at site of repair, a second operation was carried out in September, 1949. A cyst, the posterior wall of which exactly corresponded to the position of the skin implant, was found and excised and the resulting defect (no hernia was present) repaired with stainless steel wire.

The cyst contained what appeared to be a mixture of pus and sebaceous material, but which on culture proved sterile.

Histology: a transverse section of the cyst enabled a contrast to be made between that part of the wall which corresponded to the original implanted skin (*a*), the adventitious 'skin' which has developed opposite it (*b*), and the area of transition between them (*c*).

a. The epidermis was flattened, but otherwise appeared normal. The dermis contained sweat and sebaceous glands and hair follicles.

b. Flattened thin epidermis with no interpapillary processes covered collagenous fibrous tissue (in which no epithelial elements were identified).

c. Adjacent areas on either side of cyst were lined by cellular and vascular granulation tissue in which clumps of epithelial cells surrounded by lymphoid cells were clearly distinguished.

The cystic space was occupied by cellular debris, desquamated cells, and fat globules.

6. J. W. A., aged 50. Direct inguinal hernia for five years. At operation in January, 1948, a fistula was excised from patient's mouth and skin repair for right direct inguinal hernia carried out. Pyrexia 100–101° F. two days, otherwise uneventful convalescence. Slowly enlarging swelling right groin from April, 1949.

At a second operation, June, 1949, the site of the former skin implant was found to be occupied by a cyst (8 × 2·5 cm.). This bulbous sausage-shaped cyst was dissected out. It contained sebaceous material and hairs and along its posterior wall was an area of skin with a worm-eaten, serpiginous margin. Scattered hairs were seen growing apparently not only from this, but also from the opposing fibrous wall.

Histology: Three distinct zones were noted, corresponding to the residual epidermis (*a*) and its margin (*b*)—these corresponding to the graft—and the opposite wall of the cyst (*c*).

a. Flattened epithelium with little evidence of interpapillary processes covering the true dermis, showing sweat and sebaceous glands and hair follicles.

b. Epidermis is replaced by vascular granulation tissue containing occasional giant cells. In one such area, apparently forming a separate cyst, there are masses of clear foam cells and small giant cells and a few lymphoid follicles.

c. Well-developed granulation tissue laying down fibrous tissue without evidence of epithelial elements.

Contents—no organisms seen; culture sterile.

7. W. M., aged 53. April, 1948, operation for left inguinal hernia. Direct weakness and large protrusion of extraperitoneal fat. Repair with skin implant. Post-operative inflammation developed and abscess opened twelve days later. Culture: Profuse growth coagulase-positive *Staph. aureus*, insensitive to penicillin. As sinus persisted, ten weeks later sinus and portion of graft lateral to cord were excised. Portion medial to cord was not exposed as it did not appear to be connected with sinus.

Wound remained soundly healed and strong, but discomfort persisted, so in May, 1949, the whole inguinal canal was exposed. The posterior wall of the canal was covered by apparently unaltered skin, which formed the back of a flattened cystic cavity. The skin was dissected from the inguinal ligament, transversalis fascia, and conjoint tendon, and the gap repaired with stainless steel wire.

Histology: Most of the posterior wall of the cyst consisted of apparently normal skin showing epidermis and true dermis. At the margin of this area the epidermis was replaced by cellular and vascular granulation tissue in which atrophied squamous epithelium was identified, also residual sebaceous glands and hair follicles. All structures in this area showed a chronic inflammatory process with numerous giant cells.

8. J. B., aged 41. Skin-graft repair for moderately-sized, left, indirect, inguinal hernia, February, 1949. Developed local reaction to metaphen and urticaria, believed due to penicillin. Purulent discharge commenced eight days after operation, and from this a profuse growth of *Staph. pyogenes aureus* was cultured. This discharge cleared up, but recurred from time to time.

At a second operation, June, 1949, a sinus was excised down to inguinal canal, where the graft was found firmly attached in the position it had originally been placed. The graft was dissected out and a re-repair carried out with stainless steel wire.

Specimen 7 × 2·5 cm. consisted of skin with some erosion of its margin.

Histology: All the skin layers except the corneum were present and showed little change from normal. The dermis showed a moderate pericapillary, round-cell infiltration.

Culture again showed profuse growth of *Staph. aureus pyogenes.*

9. H. T., aged 48. February, 1948, skin-graft repair for bilateral, direct, inguinal hernia, three years' standing. Post-operative pyrexia 99–100° F. three days. Purulent discharge from the right wound commenced five weeks after operation. With course of penicillin this healed and remained so till November, 1948, when discharge recommenced and persisted.

At re-operation in March, 1949, the sinus was dissected out and found to lead to a space above and lateral to the cord. This space was partly lined with skin and contained hairs. The size, shape, and position of this tunnel suggested that separation of the graft from the inguinal ligament and the consequent folding of the graft may have formed a cyst and later a sinus. This epithelium (*a*) and a portion of the apparently completely incorporated medial part of the graft (*b*) were excised. The latter, taken from medial to the inguinal ring, looked like fibrous tissue.

Histology: (*a*) A portion of skin with thickening and flattening of the epidermis and sweat and sebaceous glands and hair follicles in the dermis. (*b*) Surface consists of vascular and cellular granulation tissue in which numerous giant cells were seen. No surface epithelium and only a few sweat-glands seen in the dermis. (*c*) At the junction of these two areas what may be the process of removal of the epithelium can be seen. In the granulation tissue there were small islands of degenerate squamous epithelium.

Culture: Profuse growth of *Staph. aureus pyogenes* which show *in vitro* sensitivity to penicillin.

Discussion of Cases.—Unabsorbed epithelium was suspected in 6 other cases; 2 of persistent sinus (10 months and 18 months); 3 of persistent discomfort and thickening; 1 of temporary cyst formation—five months after operation he was noted to have "a long elliptical swelling soft and deep" which was considered to be a cyst but which eight months later had completely disappeared.

The persistent epithelium was detected: (1) In association with persistent sinus; (2) As a cystic swelling; (3) At operation, e.g., for recurrence when the presence of a cyst was unsuspected.

Summary of Histological Features.—

1. The epidermis in no case completely lined the cystic cavity: in one case it was almost entirely absent and the scant remnants were degenerate; in some there was evidence that it had extended beyond the original graft, forming a flat thin epidermis, but in most it consisted of a fragment of the original graft.

2. The remainder of the cyst wall was lined by a highly vascular granulation tissue showing varying degree of organization into fibrous tissue. This granulation tissue contained giant cells and, near the epithelial margin, islands of epithelial cells; in some cases foam cells were present. Lymph-follicles were occasionally noted in the granulation tissue.

3. The pattern of the fibrous tissue of the corium could in most cases be defined. The epithelial elements in it—hair follicles, sweat and sebaceous glands—were present beneath the epidermis and

usually to some extent in the corium from which the epidermis had disappeared.

4. Organisms were cultured from the cyst contents in 1 case and were found in the discharge in the 3 cases of chronic sinus.

Factors related to Cyst Formation.—As a basis to understanding this problem it is suggested that, no matter in what manner skin is implanted in the connective tissue there is a process tending to the ultimate removal of all the epithelial elements. The presence of a persistent cyst or sinus indicates that this process has been held in check.

This process of epithelial removal would appear to be interrelated with the reaction between (1) the epithelium, (2) its products, and (3) the surrounding tissue.

The products of the epithelium—hair, fat, cholesterol, and epithelial debris—stimulate the production, by the surrounding tissue, of a granulation tissue rich in giant cells (Stewart, 1912). This granulation tissue not only removes these epithelial products but also devitalized epithelium.

When first implanted, the skin has been cut off from its blood-supply. The epithelial elements are devitalized and under optimal conditions are rapidly removed.

Should the epithelium survive till the corium is revascularized, then it will grow, and cysts, partly or completely lined by epithelium, may be produced. This will be accompanied by a rapid increase in the products of the epithelium.

These products, instead of being carried away as under normal conditions, accumulate and degenerate in contact with the epithelium. These products by their toxicity and increasing tension (Davis and Trant, 1926) lead to " maceration and necrosis " of the epithelium. The process is completed by the removal of the devitalized epithelium by the granulation tissue.

This process, it is suggested, may be arrested in one of two ways : First, a state of equilibrium may be reached between the granulation tissue and epithelium, such that the granulation tissue absorbs the products of the epithelium sufficiently for the epithelium to remain relatively healthy. Secondly, the presence of a low-grade infection results in sinus formation. This acts as a drain for the epithelial debris and so the epithelium is able to persist.

Various workers have attempted to discover on the one hand what conditions lead to cyst formation, and, on the other, what lead to disappearance of the epithelium. It is considered that the most important of these conditions are included under the following heads, which are briefly discussed.

1. The state of the original graft :—
   a. With or without epidermis.
   b. Degree of tension.
2. The environment of the graft :—
   a. Site.
   b. Sepsis.
   c. Hæmatoma.
3. Time after grafting.
4. Individual variation.

Removal of epidermis: So far as the author is aware, there is no clear-cut experimental or clinical evidence to show whether this step makes any difference to the incidence of cysts. Cameron (1936), who has done experimental work with cutis grafts in pigs, considers that the step is of value. As skin repair does entail the risk of cyst formation, it would seem reasonable to cut down the amount of epithelium implanted by removal of the epidermis.

Degree of tension: As suggested in the introduction, there is considerable clinical and experimental evidence that the degree of tension under which the graft is placed influences the behaviour of the epithelium.

When the graft is placed in muscle without tension, it folds in a U shape and regularly forms a cyst (Zimches, 1931). If the graft be placed under normal tension under a muscle sheath, then the epithelium rapidly grows over the opposing surface to form a cyst (Davis and Trant, 1926). When, however, the graft is placed under tension, then the epithelium rapidly disappears in most cases (Mair, 1945, b).

The difference in effect between normal and maximal tension may be of the same nature as that noted when skin-flaps are sutured on the surface in a similar manner—not that the tension can interfere with the blood-supply of the graft, for that has already been cut off, but it may so close the vascular and lymphatic channels that the slow interchange of electrolytes between the skin and the surrounding serous exudate is interfered with, and revascularization is retarded.

It is difficult to ensure that the graft will remain under maximal tension. True, the tension should alter little when the graft is sutured to a single fascial layer, but where, as in the inguinal canal, the graft is sutured to two different layers, one of which is subject to muscle pull, it is to be expected that the tension of the graft will vary considerably. Partial separation of the graft from straining or early absorption of stitches, may alter its tension and even enable it to fold.

Site: Though too few ventral herniæ were repaired to compare the results with inguinal herniæ, it is considered that the difference of blood-supply between the subcutaneous fat and internal oblique muscle influences the rate of incorporation of grafts in these sites.

Sepsis: Its association with destruction of the whole graft in severe cases, and persistent partially epithelial-lined sinus formation in mild cases, has been discussed. Peer (1940) reported the use of dermal grafts for filling in skull defects. Of 15 cases, 2 developed sepsis which cleared up only when the " graft was extruded or removed with an instrument ".

Hæmatoma: No association between hæmatoma and cyst formation was noted in this series. Since a local thickening and inflammatory reaction was common it may well be that some hæmatomata went undetected. In this connexion King's (1932) theory of the formation of inclusion dermoids is of interest. He suggested that epithelium grew around the wall of a hæmatoma-filled cavity.

Time after grafting: Perhaps the most interesting comment, bearing out the importance of this factor, is from the work of Davis and Trant (1926). They were able consistently to produce epithelial-lined tubes or sacs in dogs by suturing pieces of skin under a muscle sheath at the same tension as on

the body surface. They state that " forty days may be taken as the maximal time allowable for the formation of a proper cyst ", for beyond this they say that the pressure of the fluid within the cyst will cause a necrosis of the cyst lining and maceration of its epithelium.

Peer and Paddock (1937) studied dermal grafts in human subjects by removal of material at intervals up to a year. Epithelium gradually disappeared and, at a year, though a cyst was found, it contained no epithelial lining. Only sweat-glands were present and these showed degenerative change.

In one case in this series a cyst was noted clinically, which ultimately disappeared.

Individual variation: No evidence has been found to support this as a factor of importance. Bilateral cyst formation has not been noted. One case forming a cyst and re-repaired with skin did not clinically develop a further cyst. This evidence is negative, however, and may well be that certain individuals are more prone to cyst formation.

DISCUSSION

The results secured in many cases treated by skin repair were excellent; indeed, our impression was that some were considerably stronger than those secured, in similar cases, following plastic measures. Yet the recurrence rate was little or no less than those reported by workers using plastic methods. It is considered that some failures were due, in the first place, to the poor quality of the available skin, and, secondly, to the weak fibrous tissue laid down around the graft.

In different individuals the strength and elasticity of the skin varies very considerably, as is evident from the varied effect of pregnancy on the abdominal skin. The fibrous tissue of the corium may be thick or thin, tough, or brittle. Unfortunately it is often just in those cases, where the most extensive repair is necessary, that the skin is found to be of poorest quality. Indeed, it is the tendency of the skin to stretch and give that makes it unsuitable for bridging a wide gap—as can be done with tantalum mesh (Douglas, 1948)—and confines its use to acting as an additional strengthening to a simple plastic repair.

There is also a considerable variation in the fibrous-tissue formation induced by the skin-graft. This is suggested not only by the variation noted in the few cases re-operated on, but also by the marked individual difference in the degree of local inflammatory reaction immediately after operation.

It is considered, however, that the results secured by the method would be sufficiently good to justify its continuance were it not for the unfortunate complication of cyst formation—this, as already pointed out, has in our hands occurred in a significant number of cases.

In seeking a cause for cyst formation, it is easy to blame faulty technique, sepsis, hæmatomata, separation of sutures from early absorption or straining, etc., but it is considered inevitable, from the very nature of the procedure, that, in spite of the most careful technique, favourable conditions for persistence of the epithelium will occasionally occur in any large series. How easily the mechanism by which the epithelium is removed may be disturbed is perhaps borne out by a consideration of the frequency with which such structures as retention dermoids, sebaceous cysts, pilonidal sinuses, branchial cysts, epithelialized sinuses, and fistulæ occur in practice.

It is hoped that a longer follow-up will prove practicable and that this will indicate more clearly the frequency of the formation of persistent cysts.

SUMMARY

The complications and results found in the follow-up of 413 herniæ treated by the whole-skin method of repair are summarized.

[Since writing this paper, through the kindness of Mr. Eastwood Sykes I have been able to observe the results following a further 42 whole-skin repairs for inguinal hernia by this surgeon. Of these cases, seen between six and eighteen months after operation, 7 failed to report. Recurrence was noted in 5 cases; weakness in 4 cases. Clinical evidence suggestive of cyst formation was present in 3 cases. A further operation was performed on one case of recurrence ten months after the previous repair. Cystic material was found. The following is Dr. A. A. Miller's report on its histology: Sections reveal connective tissue in which there are at least two cystic cavities lined by epidermis which shows varying degrees of degeneration from derangement of the normal architecture and hyaline change to desquamation and necrosis.]

The recurrence rate was much higher than that noted by Mair in his original work on the method. In fact, the rate in this series was very similar to that reported by Marsden using the same method, and differs little from the better published figures for plastic repair.

Sepsis has not been frequently seen as a complication, but when it did not resolve it was found to be associated with persistence of the epithelium of the graft.

Cyst formation was found to be present in a significant number of cases and was suspected in several more. Details of these cases are given and the histological appearances of the cysts described.

The process of epithelial removal is briefly discussed and an attempt made to indicate and correlate the more important factors which may influence it.

I wish to thank Mr. J. R. Cameron, who first stimulated my interest in skin implants; and Mr. G. Arnott, who demonstrated the method to me, allowed me to follow up his cases, and encouraged me to do a series of my own. To Mr. R. Cunliffe Shaw and Mr. Ian Orr I am indebted for valuable criticism and suggestions. I am especially grateful to Dr. A. A. Miller, who prepared the specimens and reviewed completely my histological findings.

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VARICOSE ULCER

A STUDY OF THE DEEP VEINS WITH SPECIAL REFERENCE TO RETROGRADE VENOGRAPHY

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THE subject of varicose ulcers is as old as recorded medical history and has accumulated a vast literature, yet it is unfortunately true that our knowledge both of the cause and of the treatment of these ulcers is still far from complete, and the subject has not yet received from the medical profession the attention it should command. Bauer (1942) writes, " these ulcers cause the patients much more suffering than the physician is aware of as a rule. The latter not infrequently regards the complaint with a certain amount of disdain, that disdain which one unconsciously assumes towards morbid manifestations concerning which one knows but little, and concerning the treatment of which one is equally ignorant. The disease is regarded as commonplace and dismissed with a shrug of the shoulders ". The sting of this statement lies in its truth.

Commonplace the disease certainly is, yet perhaps because nobody dies of varicose ulcer the subject has been much neglected. But from a purely economic point of view, any study that would lead to a solution of the problem would pay handsome dividends. Roholm, quoted by Bauer (1942), estimated that in Denmark in 1937 there were between 5,000 and 15,000 patients with varicose ulcers, and that the cost to the country in treating these patients was more than two million kroner annually. Although there are no recent surveys available in this country, there would, on a comparable basis, be between 100,000 and 200,000 such patients in England and Wales at the present time, involving an annual expenditure of about £3,000,000 at the present value of money. Dickson Wright (1931) estimated that there were 250,000 such patients in the United Kingdom and also emphasized the cost.

The cost of treatment cannot be reckoned as the only economic loss to the community. Time off from work, lowered efficiency, and frequently a change to lighter work also add to the bill, and it would be impossible accurately to assess the total cost of the disease in England and Wales. This is not taking into account any of the pain, discomfort, and misery that these ulcers usually cause. Sometimes, it is true, there is little or none, but more frequently the patient has considerable pain, often severe at night and preventing sleep, and a constant aching and heaviness in the leg which may persist in spite of bandaging. Add to these disabilities the frequently offensive discharge and the discomforts of an adhesive bandage worn often for months on end, and it can be appreciated that to the patient anyway varicose ulcer is a serious disability.

Many treatments (bandaging, injection of varices, ligation of veins, lumbar sympathectomy, excision and graft, rest in bed) have been advocated and practised with varying success in the treatment of these ulcers ; but it is a general rule in medicine that the more treatments that are advocated for any condition, the less is known of its real nature, pathology, and cause. Certainly little is known about the cause of varicose ulcers, and accordingly the work that is here detailed was started in an attempt to study this aspect of the problem. It was when this work was well advanced and the findings were definite that Bauer published his recent article (Bauer, 1948) setting forth his work on similar lines. Nevertheless, as details of technique, as well as some of the findings, differ from his, it is hoped that this publication may be of value.

VARICOSE ULCER AND VARICOSE VEINS

By the very name ' varicose ulcer ' it is tacitly assumed that varicose veins are the cause of the ulceration. This idea has persisted throughout many ages, and in two widely read text-books of recent publication it is stated that varicose ulcer is the final result of long-standing varicose veins. This widely held misconception accords neither with clinical observation nor with the publications of those surgeons who have studied the problem.

Clinical observation of patients attending a ' varicose vein clinic ' shows that they can be divided into three main groups :—

1. Those with varicose veins whose skin in the lower leg is perfectly healthy.

These patients may have minimal varicosities, or, on the other hand, may have enormous tortuous varices extending from groin to foot with a positive Trendelenburg sign. They often give a family history of varicose veins, and their complaints are either of the unsightliness of their veins, or of aching pain, usually in the calf, on long standing. Seldom are the symptoms severe, and they respond well to treatment by ligation and/or injection. It is a striking fact that in those patients whose varicose veins are most prominent, where indeed their very size leads to an exclamation of amazement from nurses or students, the skin of the lower leg is nearly always soft, mobile, and healthy. (*Fig.* 422.)

FIG. 422.—Enormous varicosities on both legs with normal skin. (Group 1.)

2. Those with pigmentation, induration, and even ulceration of the leg.

Here the clinical picture is quite different. They rarely give a family history, though some give a history of thrombosis, as will be discussed later, and on the whole they are of an older age group. They complain of pain, nearly always in the ulcer if one be present, and often also of a bursting sensation in the leg, aggravated by standing or walking. Varicose veins may or may not be present, but if so are usually confined to the lower leg and are seldom of great size. This clinical picture is too well known to require detailed description, but the leathery induration, chronic œdema, and shrinking of the circumference of the lower leg "as if the leg had been for years in an iron shackle" that are often present are striking features. (*Fig.* 423.)

These patients, as is well known, are difficult to treat. Their ulcers will nearly always heal with treatment, but recurrence is common and even healing of the ulcer does not always abolish the symptoms of pain and aching.

3. Those with both ulceration and varicose veins in the thigh and leg.

Though less clear cut than the other two, the authors believe that these form a rather definite group. The varicose veins are only of moderate size, with a positive Trendelenburg test, and may be of long standing. There is usually one prominent vein on the inner side of the calf which seems to 'feed' the ulcerated area. The latter is usually small in extent and in a very constant position, on the inner side of the leg just above the medial malleolus. Often the skin of the rest of the lower leg is healthy, and chronic œdema, pain, and constriction of the tissues are not features of this type.

FIG. 423.—Induration, pigmentation, and contractions of the skin of the lower leg with ulceration. There are no obvious varices. (Group 2.)

Their response to treatment is fair and healing of the ulcer is usually rapidly obtained by bandaging and treatment of the saphenous incompetence, but recurrence is not uncommon.

Though these cases have been described as falling into three groups this is no attempt to impose a rigorous classification. Individual variation is great and the presence of obesity may make determination of the extent of the varices extremely difficult. Nevertheless it is believed that appreciation of these different clinical types, and a clear distinction between Groups 1 and 2, is essential to a realization that visible varicose veins are not the sole cause of these ulcers, if indeed they are a cause at all, and that other factors must be sought.

The same point has frequently been stressed by other authors. In 1916 Homans, in an article on 'post-phlebitic' varices, seems to have been the

first to appreciate the vital importance of previous thrombosis, and in discussing these ulcers stated that " the more prominent and tortuous the surface veins, the simpler the cure—the less noticeable the surface veins, the more malignant and resistant their attendant ulcers ".

Cokkinis (1933), in an analysis of cases from a varicose vein clinic, pointed out that only 62·5 per cent of patients with varicose ulcers had varicose veins, and criticized the use of the term ' varicose ulcers '. The same point was stressed by Dickson Wright (1931), who suggested the term ' gravitational ulcer ', which has been widely adopted, but ' varicose ulcer ', however misleading, is still the term most widely used and so has been retained in the title of this paper.

Again, Homans (1938) emphasized the absence of varicose veins in many cases of varicose ulcer and pointed out that if varices were present they often " can be counted as parts of a collateral circulation secondarily becoming varicose ". Bauer (1942), in his classical monograph on the sequels of thrombosis, stated that in his experience of cases with varicose veins as their main complaint only one-eighth showed induration and ulcers and he considered that in only 13 per cent of leg ulcers were varicose veins the cause. He quoted Birger as saying, " a very large group of ulcer cases, probably the largest, have no connexion whatever with varices ".

In a recent letter Hanschell (1949) has stressed the same point. " The great majority of patients with varicose veins, at all ages, have and have had no leg ulcers, while the great majority of patients with leg ulcer, at all ages, have and have had no varicose veins ; that in its clinical features, under all conditions, there is no discernible difference between ulcer with, and ulcer without, varicose veins."

There is thus ample evidence, to say the least, that other causes than varicose veins play an important part in the production of these ulcers, and of these probably the most important is previous thrombosis.

THROMBOSIS

As already mentioned, Homans (1916) seems to have been the first to appreciate the connexion between the development of leg ulcers and a history of thrombosis in earlier years. He noted the obstinate ulceration and associated varices in these ' post-phlebitic ' cases and was also the first to mention the ' crippling ' of the valves in the deep veins by the organization of the thrombus. Zimmermann (1935) considered that recanalization occurred after ' white leg ' and that the valves were destroyed in the process.

Edwards and Edwards (1937), in a study of the late effects of thrombosis artificially produced in dogs, gave an excellent account of the histological changes that occur in a vein after thrombosis. They showed that recanalization to a varying extent does occur and that the valves were either destroyed in this process or became so adherent to the vein wall that they were functionally useless, thus confirming Homans' clinical observation of twenty years previously.

Again, Homans (1938), writing on ' post-phlebitic ' ulcers, noted that there was little that was specific about the lesions apart from the history of thrombosis, and that they " occupied the conventional situation of most ulcers of the leg ".

The late effects of thrombosis have been best studied by Bauer (1942). Basing his findings on a long follow-up of a series of 100 cases he gave the following figures for the incidence of complications :—

No. of Years after Thrombosis	*Percentage of Cases with Indurative Lesions of the Lower Leg*	*Percentage of Cases with Ulceration*
5	45	20
10	72	52
Later	91	79

These figures are striking and call attention not only to the high incidence of lower leg induration and ulceration, but also to the time factor, which is believed to be of great importance. He described also the clinical course of the disease, and its accuracy can be checked by clinical observation in any surgical out-patient department. When the main swelling resulting from the thrombosis has subsided, the patient leaves hospital with some residual œdema and heaviness in the leg, which, although persistent, interferes little with the patient's life and activity. After a variable number of years, however, induration, increased œdema, pain, secondary varices, and finally ulceration occur, and the full clinical picture described above in Group 2 develops.

Bauer (1942, 1946), as a result of his venographic studies, concluded that recanalization of the femoral vein did not occur, and that the morbid changes in the lower leg were the result of distension and varicosity of the secondary collateral circulation in the superficial veins. This concept was strongly criticized by Homans (1946), who had seen recanalized femoral veins at operation and maintained not only that the valves were destroyed and the veins functionally useless, but that they could be tied with advantage; " it would have been better if the veins remained plugged ".

The extent to which ulceration is due to previous thrombosis is disputed by various authors. Cokkinis (1933) stated that only 10 per cent of his patients gave a history of previous ' white leg ' or ' phlebitis '. Bauer (1942), as a result of his venographic studies, believed that 87 per cent of his series of ulcer cases were post-thrombotic, while Birger (1947) considered that 40 per cent of his series were so caused. The discrepancy is, it is thought, partly due to the relative smallness of the series involved, but the more important factor is the evidence on which it is decided that a patient has or has not had previous thrombosis. Certainly the history is not reliable, as thrombosis may occur without the patient being aware that much is wrong, and the incident may be forgotten; nor, as will be shown later, does venography by the ordinary technique give all the necessary information. It seems, however, that statistical surveys on this point are likely to be of little value. The more widespread appreciation in recent years of the early signs of thrombosis and the advent and wide use of the anticoagulants has certainly resulted in a great diminution in the number of cases of extensive thrombosis in the legs. Hence, in the future the percentage of cases of leg ulcers due to thrombosis will certainly diminish, and the incidence of leg ulcers will also diminish to an extent which in the present state of our knowledge it would be unwise to forecast.

The important point, however, is that in all the series a certain proportion of the ulcers are not considered to be due to previous thrombosis, though the two groups are clinically indistinguishable. This will be further discussed later.

VENOGRAPHY

From what has already been said, it will be seen that there is definite evidence that there is one factor, namely previous thrombosis, which is known to be a cause of lower leg induration and ulcer. Further, it is known that such thrombosis results in an abnormality of the deep veins of the leg, but the exact nature of this abnormality is still in some dispute; that is to the extent to which recanalization takes place. It was decided therefore to study the deep veins in cases of varicose ulcer by venography in order to determine to what extent abnormal appearances in those veins were associated with varicose ulceration.

There are many reports of venographic studies in the literature since the paper by McPheeters and Rice (1929), who injected lipiodol into varicose veins. Dougherty and Homans (1940) mentioned the abnormal appearance of a recanalized femoral vein after thrombosis, and Baker and Sedwitz (1943) gave an excellent account of the normal anatomy of the deep veins of the lower limb as seen in venograms, and also noted the distortion of the lumen of the recanalized femoral vein. They also pointed out that calcification could sometimes be seen in the veins of the leg. Lesser and Danelius (1944) show a picture of a tortuous femoral vein in a patient who had a lower leg ulcer and gave a history of thrombosis, and also noted the 'bridging' of a block in a deep vein that was occasionally seen.

Thus attention has frequently been called to the abnormal venographic appearances in the deep veins after thrombosis, and recanalization has been noted by many observers. It seemed, however, that venography by the standard technique (with the patient lying flat on the X-ray table) did not approach the root of the problem of varicose ulcers, which surely lies in the fact of man's erect posture and the consequent factor of gravity. It was decided therefore to obtain venograms with the patient as near as possible in the erect position, and injecting the radio-opaque material into the femoral vein in the groin.

Technique.—Diodone 50 per cent is used for all these examinations, 20 c.c. for each venogram.

Ascending Supine Venogram.—The patient lies supine on the X-ray table and a venogram by standard methods is first performed after a routine diodone-sensitivity test. The method described by Mahorner (1943) is used, which consists of placing a rubber tourniquet around the leg just above the ankle sufficiently tightly to occlude the superficial veins, and then making the injection with a hypodermic needle into a vein in the foot. Any vein will do, and in a normal case the dye will always enter the deep veins. This technique is preferred to that described by Bauer (1942), as any incision in the legs of these patients may be followed by delayed healing or may even form the starting-point of an ulcer.

In some of these patients the thickening of the tissues and dearth of veins may make it extremely difficult to find a suitable vein, but if the patient is asked to stand for a moment one large enough for the insertion of a small needle will nearly always become obvious and a perfectly satisfactory picture can be obtained from such a vein. Some 50 to 60 seconds is taken over the injection, and the exposure is made between 75 and 90 seconds from the start of the injection, depending on the length of the leg. When the exposure has been made the leg is raised above the level of the body for a minute or two in order to make quite sure that no opaque material remains in it which might confuse the picture in the next stage. The purpose of performing ascending venography in all cases is to attempt to correlate the findings on descending venography with those of venography by a standard technique.

Descending Venogram.—While the first films are being developed the footboard is placed on the table and the patient asked to adjust himself so that his heels are firmly down on the board and also to turn outwards the foot of the leg being investigated. This externally rotates the hip and brings the femoral vein a little nearer to the surface. The pulsations of the femoral artery are then sought just below the inguinal ligament and a weal is raised with local anæsthetic about 1 cm. medial to this point, and the fresh films are placed in position. After the previous films have been inspected the table is then tilted to between 60° and 70° and the tube readjusted and centred to a point just above the knee.

The loaded syringe is fitted with a long needle of medium bore (18 gauge) and this is then inserted into the skin weal in a direction backwards and slightly laterally, as it has been found when exposing the vessels for arteriography that the vein tends to lie both medial and posterior to the artery. The femoral vein is found at a depth depending on the obesity of the patient, and the needle can usually be felt to enter the vein—aspiration of venous blood confirming its position. The injection is then made in 20 to 30 seconds, aspiration being performed again after 10 c.c. to confirm the position of the needle. No force is used in giving the injection, and there is a singular lack of resistance—indeed if resistance is felt the needle is probably not in the vein. As soon as the injection is completed, the needle is withdrawn and the exposure immediately made. The table is then tilted back to the horizontal position and the puncture hole covered with a gauze swab and a little pressure applied for a few moments. There is often a complaint of some pain at the site of the injection immediately, probably due to vascular spasm, but this passes off in two to three minutes. As soon as they wish, the patients are allowed up to dress, and may then leave the hospital; they are advised to take no unnecessary exercise for the next forty-eight hours.

X-Ray Technique.—In order to obtain a diagnostic picture of the whole lower limb at one exposure the following technique has been used. For the thigh and hip region a 17 × 14 film with screens has been used in the Potter-Bucky diaphragm, for the knee region a 12 × 10 film (non-screen) overlapping slightly the lower part of the 17 × 14 has been fixed to the table top immediately under the leg, and below this again and also slightly overlapping its lower part has been fixed a 15 × 6 non-screen film for the lower leg. As an abnormally wide coverage is required, no

cone has been used and the anode–film distance has been increased to 48 in. The centring point is just above the knee-joint. This technique has been used both for ascending and descending venograms.

Difficulties, Complications and Dangers.—It was with some trepidation that venography by this method was first started, as the possible dangers (extravenous injection, carrying infection from an inguinal gland into the vein, puncture of the artery) were evident. However, no such complications have occurred in a series of about 30 cases, and it is believed that if care is taken there is no danger to the patient even if extravenous injection should occur. Bleeding from the punctured vein always ceases at once with light swab pressure, and only the transient pain already mentioned and the nausea that often follows injection of diodone are common side-effects. The procedure is rather trying for the patient, and one patient fainted when the exposure was being made but suffered no other ill effects. Thrombosis after venography has been observed twice, in both cases occurring in the saphenous vein when the deep veins did not fill on ascending venography and all the contrast medium went up that vein. Swelling of the leg suggesting thrombosis of the deep veins has not been seen.

It has not so far been thought advisable to try this technique on those patients whose obesity renders the pulsation of the femoral artery impalpable in the groin, and this excludes a certain proportion of these ulcer patients. Also, failure to find the femoral vein has been experienced in a proportion of cases that have been attempted. Increasing experience has improved the percentage of successes, but there are still a small number where failure occurs. Most of these failures have been on post-thrombotic cases where the recanalized lumen is probably extremely small.

On these failures and on obese patients exposure of the vein is necessary and the patient should be admitted to hospital and the X-rays taken in the theatre with the portable machine. Under anæsthesia (local or general) the femoral vein is exposed by dissection in the groin and the injection made under direct vision with the table tilted feet down to at least 45°. Equally satisfactory pictures can be obtained by this means though it requires in-patient treatment. This is the technique of descending venography practised by Bauer (1948).

FIG. 424.—Normal ascending venogram.

FIG. 425.—Normal descending venogram.

FIG. 426.—Normal descending venogram.

FINDINGS

The Normal Picture.—

1. *Ascending.*—The normal picture of what is described as ascending supine venography is so well known that it is felt unnecessary to go into any detail. *Fig.* 424 shows such a picture, and it is worth noting that the valves may be seen as flecks in the margin of the vein shadow and that the saphenous vein is not normally filled by the technique used.

2. *Descending.*—*Figs.* 425, 426 are descending venograms of two different patients, both of whom it is believed show a normal femoral and saphenous vein. In the femoral vein the medium is held up mainly on a valve just below the level of the lesser trochanter, though some of it passes through this valve and is held up by a second valve in the mid-thigh. In *Fig.* 426 a valve in the profunda is seen which is entirely competent, and in both cases a nearly competent valve in the saphenous vein is outlined. It should be particularly noted that there is

no filling of the femoral vein below the second valve and that no contrast medium is seen in the lower thigh. It is thought that any departure from these appearances is pathological.

Abnormal Pictures.—

Case 1.—Man, aged 47. History of bilateral 'white leg' with pulmonary embolism in 1941. Treated for three months in bed. Since then his legs have always ached on standing and had been slightly œdematous, but his symptoms were mild. In 1946 an ulcer appeared on the right leg, which healed rapidly. In 1949 he had a similar ulcer on the same leg, which also healed rapidly. Examination showed a few small varicosities on both legs below the knees, and both legs showed a degree of œdema in the same area. A nearly healed ulcer with a small area of surrounding induration was present just above the right internal malleolus.

VENOGRAMS (Rt. side). (*Fig.* 427).—Ascending venogram shows filling of the saphenous vein only. (Not reproduced).

Descending venogram shows that the upper part of the femoral vein is filled and is very irregular and tortuous. Three inches below Poupart's ligament it tapers off into small and obviously abnormal vascular channels extending only to mid-thigh. The profunda is seen partly filled and the saphenous is not seen.

The authors believe that this picture represents an early stage of recanalization by multiple channels of thrombosed deep veins.

Case 2.—Woman, aged 39. History suggesting 'white leg' on the left side after the birth of her first child in 1937. In 1942 she noticed a small varicosity on the inner side of the left leg in its lower third. In 1947 after a knock the skin in this area became indurated. No actual ulcer had ever formed.

Examination showed no abnormality in the leg apart from a solitary varicosity in the area mentioned, with an area of induration and incipient ulceration around it.

VENOGRAMS (Lt. side) (*Figs.* 428, 429).—Ascending venogram shows filling of the saphenous vein only.

Descending venogram shows that the femoral vein is poorly outlined in its whole length and shows no evidence of valves. The profunda is well filled and also shows absence of valves in its main trunk. It communicates with the lower part of the femoral, which is better outlined below this level.

FIG. 427.—*Case* 1. Showing early recanalization after thrombosis of the deep veins.

FIG. 428.—*Case* 2. Ascending venogram showing filling of the saphenous vein only.

FIG. 429.—*Case* 2. Descending venogram showing incompetent deep veins. (The smaller arrow shows the communicating vein.)

The authors believe that this picture represents a later, but still incomplete, stage of recanalization of thrombosed deep veins.

Case 3.—Woman, aged 62. History of 'white leg' on the left side after an abdominal operation 25 years previously. She had no symptoms until an ulcer appeared on the inner side of the lower leg in 1948.

Examination showed no varicose veins in the affected leg but a little œdema in the lower third. An ulcer with surrounding induration was present above the medial malleolus.

VENOGRAMS (Lt. side) (*Figs.* 430, 431).—Ascending venogram shows good filling of the femoral vein which is duplicated in its mid-third and which would pass as normal.

Descending venogram, however, shows complete incompetence of both channels of this femoral vein and also of the profunda. There is reflux as far as the lower end of the popliteal vein and beyond, and no valves are visible in the main trunks. The tortuosity of the popliteal vein is very striking and its width appears greater than normal.

The authors believe that this picture represents the final stage in recanalization following thrombosis of the deep veins, with destruction of valves.

Case 4.—Man, aged 61. History of chronic swelling of the left leg for over twenty years, with recurrent ulceration in the last three years. There was no history suggestive of thrombosis and no history of any serious illnesses or operations. He had served in India and thinks he may have had amœbic hepatitis.

FIG. 430.—*Case* 3. Ascending venogram showing an apparently normal femoral vein.

Examination showed a few small varicosities in the affected leg below the knee and induration and ulceration around the ankle.

VENOGRAMS (Lt. side) (*Figs.* 432, 433).—Ascending venogram shows a very similar picture to that in *Case* 3.

Descending venogram is again similar, but the femoral vein is not so well demonstrated. The complete absence of valves is noteworthy, as is also the communication between the profunda and the upper part of the popliteal (as in *Case* 2).

The authors believe that this also represents a late stage in thrombosis with recanalization in spite of the negative history.

Case 5.—Man, aged 28. History that at the age of 18 he had his first lower leg ulcer. Since then he has had repeated ulcers on both legs in spite of continuous bandaging. He had never noticed any varicose veins. There was no history suggestive of previous thrombosis, though at the age of 14 he had been confined to bed for four months with rheumatic fever.

Examination showed typical dermatitis, induration, and shallow ulceration on both legs. No œdema or varicose veins were noted and his W.R. was negative.

VENOGRAMS (Lt. side) (*Figs.* 334, 435).—Ascending venogram was essentially normal.

Descending venogram shows a smooth regular femoral vein with valves present but obviously incompetent, and there is reflux as far as the mid calf. The profunda and saphenous are not seen.

Case 6.—Man, aged 32. History of varicose veins in both legs for eight years, worse on the left side. Minimal symptoms, which responded to injection of varices. In 1947 he noticed a recurrence of varicose veins, and in 1948 he developed an ulcer on the left leg. This healed in ten weeks, but recurred recently.

Examination showed varicose veins of moderate severity more marked on the left side and an area of induration with central ulceration above the medial malleolus on the left leg. Trendelenburg's sign was positive on the left side. The sapenous vein appeared to lead directly to the ulcerated area.

VENOGRAMS (Lt. side) (*Fig.* 436).—Ascending venogram normal (not reproduced).

Descending venogram shows a picture similar to *Case* 5 except that the profunda is also filled in this instance and also shows incompetent valves. The saphenous is not seen. (This case was done by exposure of the vein in the theatre, and the dissection caused spasm of the saphenous vein.)

Case 7.—Man, aged 36. History of varicose veins in both legs for twenty years, greater on the right side.

Examination showed varicose veins in both thigh and leg on the right side, and positive Trendelenburg test. The skin of the lower leg was perfectly healthy.

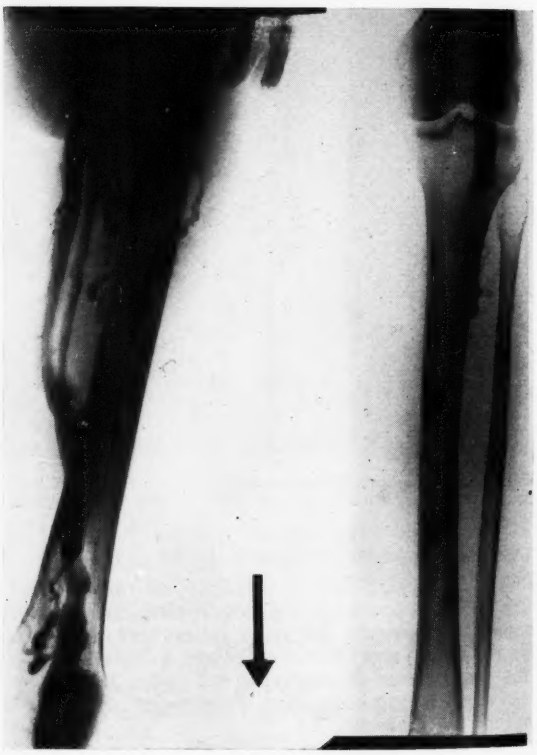

FIG. 431.—*Case* 3. Descending venogram showing incompetence of the deep veins. There are no valves visible.

VENOGRAMS (*Fig.* 437).—Ascending venogram normal (not reproduced).

Descending venogram: The femoral vein is smooth and regular, and valves are well seen. There is reflux a little farther down the thigh than in the normal picture, but in the lower third of the thigh a valve is present, and below this there is the merest trickle of dye in the vein. The saphenous vein, well seen, is obviously incompetent.

DISCUSSION

The correct interpretation of venograms is notoriously difficult, but from the cases quoted here and from the other cases that have been studied it is felt that certain conclusions are justified :—

1. *That after thrombosis of the deep veins of the leg recanalization (with destruction of valves) does occur in the majority of patients.*

The rate at which it does so varies, but it is certainly a slow process, probably occupying at least twenty years and sometimes longer before it is

FIG. 432.—*Case* 4. Ascending venogram showing an apparently normal femoral vein duplicated in its mid-part.

FIG. 433.—*Case* 4. Descending venogram showing total incompetence of the deep veins. (Note the communicating vein.)

FIG. 434.—*Case* 5. Normal ascending venogram.

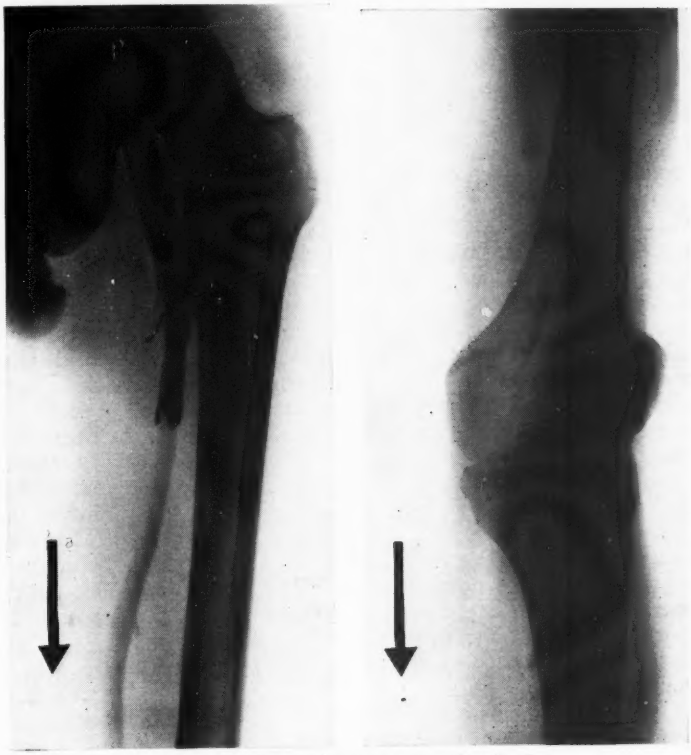

FIG. 435.—*Case* 5. Descending venogram showing incompetent femoral vein with valves present.

complete. *Case* 1 showed minimal recanalization after eight years, while *Case* 2 showed a considerably greater degree after eleven years. Another patient showed a picture similar to *Case* 2 after nineteen years. *Case* 3 showed complete recanalization after twenty-five years, while another patient, thirty years after a thrombosis, showed the process to be not quite so complete as in *Case* 3.

Certainly in all the post-thrombotic cases that have been studied there has been evidence of recanalization. This is in agreement with the observations of Linton and Hardy (1948), who, in a series of

FIG. 436.—*Case* 6. Descending venogram showing incompetent deep veins. (Note valve in the popliteal vein.)

FIG. 437.—*Case* 7. Descending venogram showing incompetent saphenous vein.

84 post-thrombotic cases explored surgically, found evidence of recanalization of the femoral vein in all cases. It can be said with certainty, however, that venography by the ordinary methods is inaccurate and misleading on this point, as shown by *Cases* 1 and 2. It seems likely that recanalization proceeds from above downwards, probably by the formation of small channels that later enlarge and coalesce, and that not until a channel has formed throughout the whole length of the thrombosed vein can that channel be seen by ordinary venographic methods.

2. *That the occurrence of previous thrombosis cannot be excluded either by the patient's history or by a venogram by the ordinary technique.*

This is well shown by *Case* 4, whose history did not suggest previous thrombosis and whose ascending venogram was within normal limits. The descending venogram in this case shows a picture which the authors believe to be typical of previous thrombosis, both from the absence of valves and the irregularity of the vein.

3. *That, on the whole, the development of intractable ulceration and serious symptoms after thrombosis is delayed until recanalization is far advanced.*

This conclusion is more arguable, as there are certainly cases, as in *Case* 1, where ulceration occurs when recanalization is far from complete. Undoubtedly other factors play a part here, and of these the inadequacy of the collateral circulation and vasospasm are probably the most important. Bauer (1942) showed that the residual symptoms after thrombosis depended on the efficiency of the collateral venous circulation—if this was high then symptoms were minimal, while if it was low, chronic œdema persisted and induration appeared earlier. Ochsner and DeBakey (1949) believe that persistent vasospasm is the underlying factor in residual œdema after thrombosis, and recommend sympathectomy in selected cases, having had good results. While œdema may persist in some cases, and even ulcers form, it has been the authors' experience that in such early cases healing is rapid, and that the more severe sequelæ of thrombosis are longer delayed and seem to develop as recanalization becomes complete. This view is also put forward by Linton and Hardy (1948).

It is certain that the circulation in the limb must be seriously disturbed by such recanalization, as there is then an unbroken column of blood unsupported by valves from the right auricle to the lower leg when the patient is in the erect position. The venous pressure in such a leg would thus be abnormally high and stasis severe, and this would account for the frequent development of bursting pain, œdema, induration, and ulceration.

4. *That in other cases showing induration and ulceration where previous thrombosis has not occurred, similar femoral vein insufficiency with back-pressure can be demonstrated and is probably the causative factor.*

Case 5 is an excellent example of this type of case, which is not uncommon, where the complete absence

of varicose veins and the severe skin changes form a striking clinical picture which has been described as Group 2 earlier in this paper. *Case* 6, though showing a similar venogram, had obvious saphenous incompetence and the skin changes in the lower leg were less severe and of smaller extent, and would be classified as Group 3. In both these groups the authors believe that valvular incompetence in the femoral vein is an important factor in the aetiology.

The cause of this valvular incompetence is not known. Both the cases quoted were young men, and a congenital inadequacy of the valves is a possible explanation of this syndrome in young patients. In elderly patients a degenerative process in the vein with secondary valvular incompetence would seem more likely, but further research on this point is needed.

5. *That in patients presenting with varicose veins in whom the skin of the lower leg is healthy, the femoral vein is normal or nearly so.* (*See Case* 7.)

It seems likely that saphenous incompetence with obvious varicose veins may occur with or without associated deep vein incompetence. It is the latter factor which determines the venous stasis in the lower leg and predisposes to ulceration, and the high pressure in the deep veins may well be the factor causing the recurrence of varicosities not infrequently seen after adequate saphenous ligation.

FIG. 438.—Ascending venogram in the erect position. Normal subject at ½ min.

The above conclusions are based on the study of a series of about 30 patients. It is fully realized that this is a very small number from which to make deductions. Nevertheless, the findings have been very constant and are in general agreement with those published by Bauer (1948) and the authors believe that they are valid. Many facets of the problem of ulceration and its causes remain to be examined, and the factors of vasospasm, collateral circulation, saphenous incompetence, and femoral incompetence all need further study before the full answer can be known. The belief that the work here published may stimulate the interest of others in this subject is the reason for the publication of so small a series.

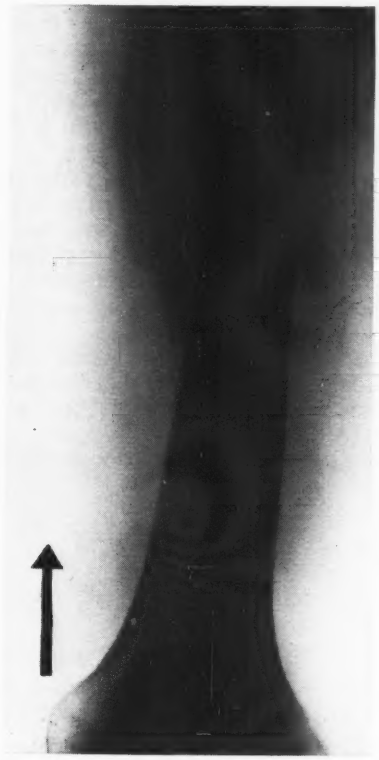

FIG. 439.—Same subject at 1½ min.

Treatment.—If, as the authors believe, the main factor in the causation of these ulcers is femoral vein incompetence, the question of their treatment by ligation of the femoral vein logically arises, but it must not be forgotten that in the majority of leg ulcers treatment by bandaging gives satisfactory results. Such treatment is safe, does not require admission to hospital, and has no disagreeable sequelæ. It is only in cases where this treatment has failed that more complex measures should be undertaken. For instance, *Case* 3, quoted above, although showing complete femoral vein incompetence, healed in three months and has remained healed and symptom-free with support from a crêpe bandage.

In a proportion of these ulcer cases, either healing does not occur, or there is rapid recurrence of ulceration, or severe symptoms persist in spite of healing of the ulcer. It is in such cases that other measures may be necessary. Lumbar sympathectomy has been tried frequently, and where there is vasospasm good results are to be expected. Ligature of the deep veins has also been tried and there are several reports in the literature. Buxton, Farris, Moyer, and Coller (1944) and Buxton and Coller (1945) reported their results of femoral vein ligation and found that pain was relieved and the ulcers healed, but swelling might be increased. Homans (1946) advocated femoral vein ligation in post-thrombotic cases only for those patients with bursting pain, and Linton and Hardy (1947) reported encouraging results from combined

femoral and saphenous ligation, though they gave few details. In their later paper (Linton and Hardy, 1948) they give a more detailed report of their results, though the longest follow-up is sixteenth months. They report healing of ulcers in 80 per cent of cases, relief of pain in 63 per cent, relief of œdema in 45 per cent, and disappearance of induration in 37 per cent. Bauer (1948) advises ligature of the popliteal vein, and his results are even more encouraging, pain and ulceration being relieved in 100 per cent and 90 per cent of cases respectively, though in his cases also the follow-up is short.

The authors have, as yet, no experience of the operation of deep vein ligation, but believe that it is indicated in cases where symptoms are severe or ulcers recurrent, and where deep vein incompetence is shown to be present. It is thought that popliteal vein ligation is the treatment of choice for two reasons :—

1. A communication between the lower end of the profunda and the upper end of the popliteal vein can be demonstrated in some of these patients (*see*

FIG. 440.—Ascending venogram, taken 3½ mins. after injection, in a patient with a patent but incompetent deep vein.

Figs. 429 and 433, *Cases* 2 and 4). If the superficial femoral vein were tied in such a case the communicating vein would probably enlarge and the relief of venous back-pressure would be short-lived.

2. Studies of the return venous flow from the foot in the erect position in these patients show that the popliteal vein plays little part in this process, and its ligation is thus unlikely to worsen the venous return. *Figs.* 438 and 439 are ascending venograms of a normal subject in the erect position, taken ½ min. and 1½ min. after injection into a vein in the foot, the progress of the contrast medium being watched on the screen. The return flow is seen to be via the popliteal and femoral veins, which are well outlined, and no medium was visible in the leg at 2½ min. *Fig.* 440 shows a picture taken by a similar technique in a patient with a patent but incompetent deep vein, 3½ min. after injection. There is considerable residue of contrast medium below the knee and only faint outlining of the popliteal vein. Such clearance as could be observed was by way of the smaller collateral veins only. There appeared to be no upward flow in the main deep veins, and similar stasis was still seen at 5 min.

From these and similar cases, it seems probable that the high pressure in the popliteal vein prevents blood from draining into it, and the return venous flow from the lower leg is by small channels. The patency of the popliteal vein in such cases is actually harmful, being the main channel through which venous back-pressure is transmitted.

Thus ligation of the popliteal vein appears to be the operation of choice in patients with deep vein incompetence and where other indications warrant its performance. Only a long and careful follow-up will show if the results are permanent, but the authors believe that there is sufficient evidence to justify an extensive trial of the operation. The paper by Bauer (1948) is most encouraging, and it is to be hoped that further trial will justify an operation that holds out more hope for these unfortunate patients.

SUMMARY

1. The incidence of varicose ulcers, the disability they cause, and their economic cost are assessed.

2. It is stressed that these ulcers are *not* caused by varicose veins, and that both clinical observation and a perusal of the literature confirm this statement.

3. The known facts about previous thrombosis as a cause of these ulcers are reviewed.

4. A technique of venography is described, injecting the contrast medium into the femoral vein at the groin with the patient in the erect position. The advantages to be gained by this method in studying the anatomy and function of the deep veins are indicated.

5. Selected cases from a series studied by this technique are described and illustrated.

6. The conclusions drawn are as follows :—

a. That recanalization does occur in the deep veins after thrombosis.

b. That venography by ordinary techniques does *not* give accurate information on this point.

c. That the occurrence of recanalization is of the first importance in the aetiology of ulcers and other severe post-thrombotic sequelæ, and leads to the destruction of the valves in the femoral vein with subsequent incompetence.

d. That incompetence of the valves may also be found without any previous thrombosis and may give rise to an indistinguishable clinical picture.

7. The treatment of this syndrome by ligature of the deep vein is discussed.

We are grateful to the members of the staff of Westminster Hospital for allowing us access to their

clinical material and for the facilities they have afforded us in carrying out this work. We wish particularly to thank Sir Stanford Cade and Mr. E. Stanley Lee for their help and encouragement in the preparation of this paper, and Dr. Peter Hansell for producing the illustrations.

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CEREBRAL ANGIOGRAPHY

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HISTORICAL DEVELOPMENT

EGAS MONIZ introduced cerebral angiography in 1927, with the assistance of Almeida Lima. The first contrast medium employed was sodium iodide, but this gave rise to fits and other reactions. Thorotrast was substituted later (Egas Moniz, Pinto, and Almeida Lima, 1931; Egas Moniz, 1933, a, b). It proved satisfactory from the radiographic point of view and gave rise to no immediate reactions. Egas Moniz and his school made crude measurements of the circulation time by means of Pereira Caldas' "radio-carousel", a rotating casette capable of taking up to six serial exposures in 6 seconds (Egas Moniz, Almeida Lima, and Pereira Caldas, 1934).

Egas Moniz and his colleagues worked out a routine angiographic technique, which remained in general use for almost twenty years, and they also established the basic normal appearances of the arterial and venous circulation. They applied the method in the diagnosis of tumours, aneurysms, angiomas, and other conditions. The results of this large volume of work were reviewed by Egas Moniz in his monograph *L'Angiographie Cérébrale* (1934) and later in "Die Cerebrale Arteriographie und Phlebographie" (1940). Almeida Lima (1938) and Imaginario (1944) studied the angio-architecture of intracranial tumours, and Egas Moniz (1947) presented a brilliant angiographic study of thrombosis of the internal carotid artery.

The method was soon studied by the Germans. Löhr and Jacobi (1933) developed the combined use of arteriography and pneumo-encephalography. Fischer (1938; 1939) produced careful studies of the angiographic pattern of frontal lobe gliomas. The vascular pattern and displacements of tumours were studied by Tönnis (1939) and Lorenz (1940). Riechert (1939) and Wolff and Schmid (1939) reported its use in the diagnosis of intracranial aneurysms.

The rapid development of the method on the Continent was not paralleled in England or the U.S.A. Following the first reports in English literature (Egas Moniz, 1933, b), Dott used it in the diagnosis of intracranial aneurysms (1933). But the potential danger of the radio-activity of thorotrast, which lodged permanently in the reticulo-endothelial cells of the liver and spleen, was recognized and the disturbing findings of damage to the cerebral blood-vessels, first noted by Northfield and Russell (1937) and later confirmed by Ekström and Lindgren (1939), were also a deterrent to the widespread use of the method.

Recognizing the need for a non-radio-active contrast substance which was eliminated from the body, Gross (1940) first reported the clinical trial use of diodone following satisfactory animal experiments (Gross, 1939). More extensive tests (Gross, 1941, b) showed that it was a satisfactory medium. In Norway the experimental work of Kristiansen and Cammermeyer (1942) indicated that diodone produced no apparent damage to the cerebral blood-vessels, but Broman and Olsson (1948, 1949) have shown that it does so experimentally, if used in concentrations of 50 per cent or more.

The rapid development and widespread use of cerebral angiography in the last few years is due largely to the substitution of diodone for thorotrast, and to the perfection of the percutaneous technique. The percutaneous method was first used for angiography by Loman and Myerson (1936). They were already skilled in the technique of carotid puncture, which they used in their treatment of neurosyphilis (Hirsch, Myerson, and Halloran, 1925) and in clinical experiments (Damashek and Loman, 1932). They were soon followed by Shimidzu (1937), Turnbull

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(1939), Wolff and Schaltenbrand (1939), Takahashi (1940) and Domnick (1940). However, it is mainly to the centres of Oslo and Stockholm that we owe the present ever-widening use of this method. They combined the use of diodone with the percutaneous method and thus avoided the dangers of the deposition of a radio-active substance in the neck (Kristiansen and Emblem (1944) in Oslo; Lindgren (1947) and Wickbom (1947; 1948) in Stockholm). In recent years several comprehensive reports have appeared setting out the diagnostic value of angiography (Engeset, 1944; List and Hodges, 1946, a, b, 1947; Hodes, Perryman, and Chamberlain, 1947; Wickbom, 1948; Almeida Lima, 1950).

Up to October 31, 1949, 720 angiographic investigations, calculated in terms of sides injected, have been carried out in this department and *Table I* illustrates the rapid growth of our use of this method.

Table I

Year	1945	1946	1947	1948	1949 (Jan. 1–Oct. 31)
No. of sides injected	18	109	150	206	186

From experience in many countries it has been abundantly established that with reasonable precautions cerebral angiography with diodone is a safe and effective diagnostic method.

I. TECHNIQUE

THE PERCUTANEOUS TECHNIQUE

From the beginning of 1948 the percutaneous method has gradually replaced the operative method and is now our standard procedure. The carotid artery is exposed only if the percutaneous technique fails or if there is some special indication, such as a proposed carotid ligation. In the ten-month period ending Oct. 31, 1949, 176 percutaneous punctures were performed with 4 failures.

The method has been well described by Lindgren (1947), and in general his technique is followed in this department.

Apparatus.—This consists of an 18-gauge needle 4 in. long for the arterial puncture, a length of pressure tubing with an intervening glass connexion, two ordinary smooth-running 20-c.c. syringes for the injection of saline, a special 20-c.c. syringe with finger-grips for the injection of the contrast substance, and Ringer's solution to which is added sodium citrate to make it a 0·38 per cent solution.

Team.—It is necessary to have an operator to puncture the artery, an assistant to inject, and a nurse to clean and refill the syringes. Wilkinson, Stanton, Jones, and Spalding (1949) have recommended a team of four, on the ground that once the needle is in the artery it should be constantly held by one member of the team who does nothing else. We consider that once in the lumen of the artery the needle is safer left alone.

Premedication.—Injection of the contrast medium produces a burning sensation in the distribution of the vessel which is being injected. If the patient is under light general anæsthesia there is often a sudden movement of the head at that time, which coincides with exposure of the films. Consequently it is better to work with a conscious patient under omnopon ($\frac{1}{3}$ gr.) and scopolamine ($\frac{1}{150}$ gr.). If there is a history of fits, phenobarbitone is given. In cases of high intracranial pressure, if drowsiness and slowing of the pulse are present, intramuscular phenobarbitone or paraldehyde is less likely to precipitate coma. In children and in uncooperative or mentally deranged patients general anæsthesia is necessary.

The Arterial Puncture.—It is easiest to puncture the artery at that part which feels most superficial and is most easily palpated. This is generally situated about the level of the upper border of the thyroid cartilage and, if the puncture is made here, the region of the carotid sinus or commencement of the internal carotid artery is almost always entered. In about 5 per cent of cases the needle enters the external carotid artery, and then repuncture at a lower level is necessary. This lower level is chosen initially if filling of the external as well as the internal carotid circulation is desired, as in suspected cases of meningioma.

Local anæsthetic is placed in the skin only, about 2 cm. lower in the neck than the anticipated site of arterial puncture, to allow for the oblique direction of the needle. Infiltration of the deeper tissues obscures the pulsation of the artery. Little pain is caused by manipulating the needle unless the point passes deep to the artery and stimulates the deep cervical nerves. The greatest discomfort is a choking sensation caused by pressure with the fingers of the left hand when fixing the artery.

The needle must be perfectly sharp and should be used only once before re-sharpening. To prevent the point becoming blunted, the initial puncture of the skin is made with another needle.

The greatest obstacle to successful puncture is the tendency for the artery to roll away from the needle point. Hyperextension of the neck decreases the mobility, but too much hyperextension makes it difficult to feel the artery. An additional method of fixing the artery is by pushing it, with the fingers of the left hand, into the sulcus formed by the bodies of the vertebræ and their transverse processes.

When the point of the needle comes into contact with the artery the pulsation is transmitted to the right hand. This should be felt immediately beneath the point and not from one or other side, or the artery will tend to rotate and the needle will slip past. The needle should be thrust steadily and without a jerk, as this may also push the artery aside. Usually the artery is transfixed and on slowly withdrawing the needle the point is felt to slip out of the posterior wall into the lumen.

Once the needle is in it may be safely left undisturbed, and frequently it advances along the lumen of the vessel as if sucked in by the arterial pulsations.

Method of Injection.—With the needle in position, the assistant slowly injects the saline solution to prevent clotting in its lumen. The injection of diodone should be smooth, uniform, and rapid, at the rate of about 5 c.c. per second. Rapid serial angiography has shown that each assistant, when using the syringe, soon attains a uniform rate of injection. Ten to twelve c.c. of contrast substance are sufficient to fill the vessels adequately, with proportionately smaller quantities for children.

When the injections are completed and the needle is withdrawn, the site of puncture should be pressed upon for a few minutes to minimize the risk of hæmatoma.

Protection.—Lindgren (1947), Engeset (1948, a), and Wickbom (1948) have drawn attention to the necessity for adequate protection from X rays of personnel engaged in angiography. This is especially important when using the rapid serial method, where the primary dose is much increased. The protective lead screens used in our department are modified from Lindgren's design.

Complications.—

1. *Perivascular Hæmatoma* (*Fig.* 441).—Sometimes while the needle is in the artery there is leakage of blood around it into the tissues. If this tends to

become large it is better to withdraw the needle and repeat the examination in a few days' time. A hæmatoma may also form in the neck when the needle is withdrawn, but if the artery is carefully compressed this occurs in less than 10 per cent of cases.

With a large hæmatoma there may be some tracheal deviation, but in our series only one has caused respiratory embarrassment. This patient

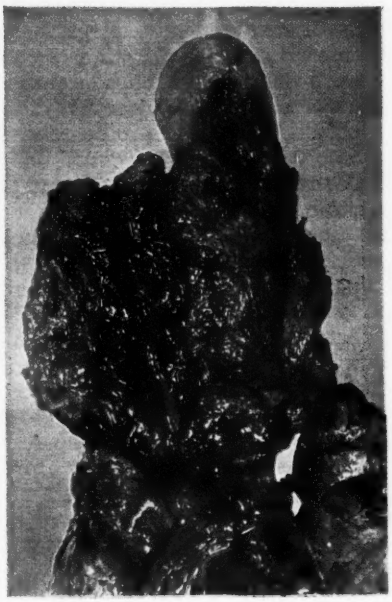

FIG. 441.—A moderately large perivascular hæmatoma of the carotid sheath. Death occurred 48 hours after percutaneous angiography and was caused by an inoperable intracranial tumour. The hæmatoma has been opened up to display the carotid artery lying within it and the blood has tracked down the sheath towards the mediastinum.

had gross hypertension and palpable calcification in his carotid artery. The hæmatoma reached large proportions and caused some respiratory embarrassment. Some 30 to 40 c.c. were aspirated with relief. Such a case is probably unsuitable for angiography by any method.

The hæmatoma disappears with surprising rapidity, generally within 24 to 36 hours, though not so much by absorption as by tracking down the carotid sheath into the mediastinum.

The possibility of a hæmatoma emphasizes the necessity for a strict aseptic technique.

2. *Formation of Clot in the Needle.*—Before we took special precautions to prevent it (q.v.) a small fibrinous clot frequently formed in the lumen of the needle (*Fig.* 442). With experience the assistant could suspect its presence. If resistance to the flow of saline develops it is due either to the formation of clot or to the needle coming partly out of the artery. If appropriate gentle manipulation of the needle does not cause the obstruction to disappear the needle is always removed for fear that further injection of contrast medium—and this is always done with considerable force—might cause a clot embolus, which, we believe, is the most likely explanation for some of the hemiplegias which have occasionally been reported elsewhere.

To prevent clot formation two measures have been carried out, on the advice of Dr. R. G. Macfarlane* :—

a. To the Ringer's solution is added sodium citrate to make a 0·38 per cent solution. This is insufficient to affect the clotting time when diluted in the blood-stream, but is sufficiently concentrated to discourage clotting in the needle.

b. The needles are 'siliconed'.† This process involves the deposition of a monomolecular film of a silicone on the surface of the metal and makes it unwettable. Since doing this we have had no instance of clot forming in the needle.

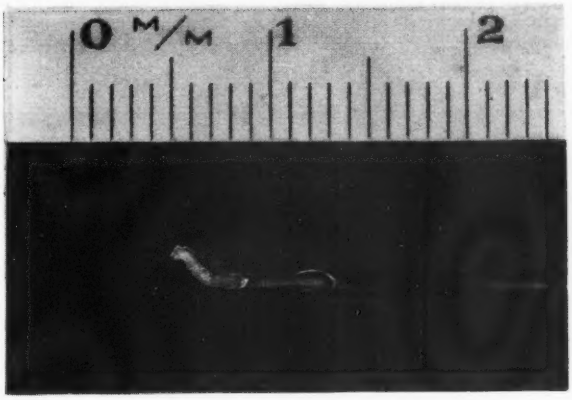

FIG. 442.—Fibrinous clot from the lumen of the needle. During angiography resistance to the flow of saline was noticed by the assistant, and the needle was promptly withdrawn from the artery. Such a clot is not seen until it is extruded by passing a stylet.

3. *Damage to the Vessels.*—This must be rare. In the few post-mortem specimens which we have seen there has been no evidence of intimal damage to the artery, or of subintimal hæmorrhage (*Fig.* 443). We have had no evidence at any time that the needle has punctured the internal jugular vein, but probably it is occasionally punctured. No cases have formed an arteriovenous fistula and none has been reported elsewhere, but, as it may take years to develop, sufficient time has not yet elapsed for this complication to be excluded (Elkin, 1948).

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† The silicone used in the Hæmatological Department of the Radcliffe Infirmary is made by the General Electric Co. under the name of Dri-Film 9987. It is a fairly mobile liquid which fumes in moist air, producing hydrogen chloride. Owing to this, it is corrosive and should be handled with care. Any large quantity of silicone should be dispensed in as many small bottles as possible. Once a bottle is opened it is very difficult to close it again in such a way as to make it moisture proof. Rubber bungs and metal caps are attacked by the fumes and by the liquid itself.

The needles should be clean and dry. The lumens should be burnished with stainless steel wire. They are then siliconed by filling and covering the external surface with the liquid. They are drained on a piece of filter-paper for a few minutes and finally treated with a large volume of distilled water. This brings about the hydrolysis of the compound and also removes all traces of hydrochloric acid. The quality of the surface improves with repeated treatments. The use of this method to discourage clotting was first reported by Jaques, Fidlar, Feldsted, and Macdonald (1946).

CONTRAST SUBSTANCE

During the last five years a preparation of diodone * has almost completely replaced thorotrast in this department. It is not radioactive, and is rapidly excreted by the kidneys. Gross (1939; 1940; 1941, a) first used it for angiography. Ingraham and Cobb (1947) and Hodes, Perryman, and Chamberlain (1947) have carefully compared the relative radio-opacity and toxicity of the substances.

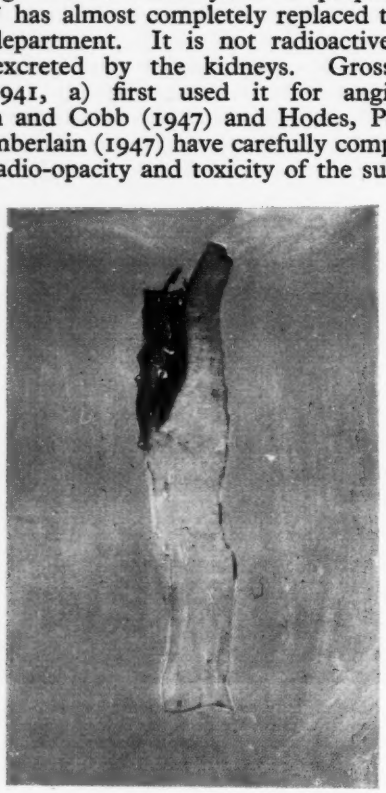


FIG. 443.—The appearance of the intima of the common carotid artery 72 hours after percutaneous angiography. There are two scarcely visible puncture marks near its upper end, without any mural thrombosis or subintimal hæmorrhage. Between the internal and external carotid arteries there is a small perivascular hæmatoma.

With careful radiographic technique we have found a 35 per cent solution of diodone sufficient for diagnosis. Stronger solutions tend to produce convulsions (Gross, 1941, a) and damage the cerebral capillary bed (Broman and Olsson, 1948, 1949) and are not necessary even for the anteroposterior projection. Good as 35 per cent diodone is, it is not perfect, as Olsson (1949) has also shown, and a more inert substance should be sought.

Häussler, Dörung and Hämmerli (1940) reported from Germany the use of a solution of ethyl-triiodine-stearate which was named 'Vasoselectan'. It has the same density as thorotrast and they stated that it was excreted by the body in a few days. It is unobtainable in England and this department has had no experience in its use.

Complications with Diodone.—

1. *Sensation.*—A burning or hot sensation is experienced by the patient during the time the contrast is passing through the cerebral vessels. This has great individual variation, from a "hot wave" to a "red-hot needle". The site of the pain is helpful; if experienced in the eye it generally indicates adequate filling of the internal carotid. The pain in the eye is sometimes accompanied by a flash of light, and this is probably due to retinal stimulation; neither the pain nor the flash of light is experienced during vertebral angiography when there is adequate filling of the posterior cerebral arteries.*

2. *Sensitivity* to the diodone is sometimes observed. It may be tested for by the intradermal, intra-ocular or intra-oral method, but none is foolproof. Pendergrass, Chamberlin, Godfrey, and Burdick (1942) reviewed 661,000 intravenous injections with a total of 37 deaths; at least 17 of these were due to diodone. Dolan (1940) reported death following the injection of 3 c.c. intravenously in a test injection in a patient with an asthmatic history. Goldburgh and Baer (1942) reported a case in which there was an attack of asthma seven days after the first injection, and death followed a second injection two days later, although the intra-oral test was negative. Other workers have found the intradermal test to be only 80 per cent accurate.

Milder degrees of sensitivity are sometimes encountered, such as skin flushes, urticaria, nausea, and vomiting. In one case a probable mild attack of asthma was provoked, although the intra-oral test was negative. This patient had no asthmatic history but had shown a previous sensitivity to morphine. In another case urticaria resulted, but it was only transitory. At repeat angiography one year later thorotrast was used with no reaction. As the condition was one of recurrent frontal glioma it was decided that the remote dangers of thorotrast were not a contra-indication. A more serious and unusual type of sensitivity was encountered in the following case.

M. C., R.I. 75394/47. Female, aged 34 years. On November 5, 1946, this patient had the right common carotid artery ligated elsewhere following the clinical diagnosis of an aneurysm of the right internal carotid artery. Her symptoms of progressive loss of vision, headaches, and bilateral external rectus palsy persisted.

On July 30, 1947, left carotid angiography was performed by the open method. A perivascular sheath injection was made inadvertently and immediately following this she complained of unusually severe pain in the neck. Although the intra-oral sensitivity test had been negative, she felt nauseated, vomited, and showed signs of collapse, with pallor, sweating, and a rapid pulse. No further injections were made and she quickly recovered from this state. She continued to complain of severe pain in the neck, jaw, and precordium for some days. On the fifth day a papulopustular rash appeared over the vascular distribution of the left external carotid artery and around the wound. Culture from the wound in the neck revealed some pus cells and a growth of *Staph. aureus*. On the eighth day a secondary hæmorrhage occurred from the site of puncture of the common carotid artery. This was not finally controlled until the tenth day, when the common carotid artery was ligated low in the neck. This produced no neurological complications and the patient recovered satisfactorily from this episode. Biopsy revealed a carcinoma of the nasopharynx invading the base of the skull, and the patient died four months later from this condition.

There have been no deaths in our series from sensitivity. After 100 consecutive angiographies we abandoned sensitivity tests, but an asthmatic or allergic history is always sought. If present we

* The preparation of diodone used in this department is Pyelosil, Glaxo Laboratories Ltd.

* During vertebral injection the patient may complain of transitory vertigo.

regard it as an absolute contra-indication to the use of diodone, and thorotrast is then used if the indication for angiography is sufficiently strong.

3. *Convulsions.*—With a 35 per cent solution of diodone 4 of our series of 346 patients since January, 1947, developed an epileptic attack within a few minutes of the injection. Three of these patients had already suffered from epileptic attacks during the course of their illness, and after the injection they had only one fit. The fourth patient, with no previous history of epilepsy, had several fits over the succeeding 24 hours. In another case an epileptic attack occurred immediately before an injection was to be given; intramuscular phenobarbitone was administered and ten minutes later the injections of diodone were made without incident.

4. *Elevation of the Blood-pressure.*—Gross (1940) noted in experimental animals that intra-arterial injection of diodone caused a transitory rise of blood-pressure. We have confirmed this in the human in 8 cases tested (*Fig.* 444). The rise of blood-pressure occurs within less than a minute of the injection and lasts only for 1 to 2 minutes. It is followed immediately by vasodilatation of the small vessels of the conjunctiva. The rise in blood-pressure occurs before there is likely to be direct stimulation of the general vascular bed and probably results from direct stimulation of the carotid sinus receptors. Injections of saline and thorotrast, on the other hand, do not affect the blood-pressure.

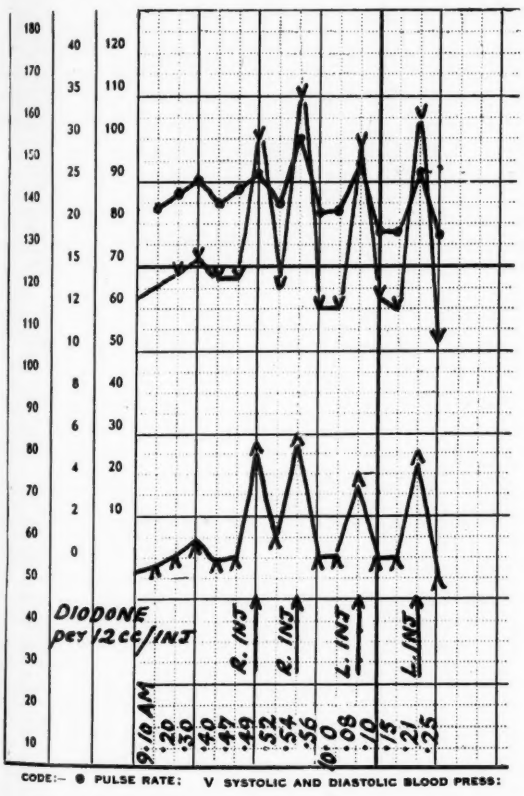


FIG. 444.—Blood-pressure and pulse readings during percutaneous carotid angiography. With each injection (↑) there is a brief sharp rise of systolic and diastolic pressure and a slight rise of pulse-rate. These readings were taken in the first half-minute after the intra-arterial injection of diodone.

5. *Vascular Spasm.*—The irritant property of diodone may be responsible for the complication which resulted in the following case :—

E. W., R.I. 102582/49. Male, aged 67 years. Two years before admission this patient had suffered from a coronary thrombosis, and three months before admission he complained of the sudden onset of 'pins and needles' in his left hand, followed by persistent weakness and clumsiness. Subsequently he had several more attacks of 'pins and needles', each lasting a few minutes. On examination he showed a left lower facial weakness and weakness of the left thumb and index finger, with a considerable cortical sensory loss in the left hand. His blood-pressure was 170/95 mm. Hg, and his peripheral vessels showed moderate thickening. On May 18, 1949, right percutaneous carotid puncture was carried out. Following one injection of 12 c.c. of 35 per cent pyelosil he developed a focal fit involving the left arm and leg. There was transitory loss of consciousness followed by stupor. No more injections were made and he was given phenobarbitone (3 gr.) intramuscularly. Later in the day he complained of poor vision in the right eye, but next day this had improved. On May 20 the ophthalmologist diagnosed a spasm of the right retinal artery and antispasmodic treatment was begun. Some recovery of vision took place, but on discharge from hospital on June 6 there was still a central scotoma of that eye.

6. *Renal Damage.*—Diodone is rapidly excreted within a few hours by the normal kidneys, even when injected in quantities up to 90–100 c.c. Its use is absolutely contra-indicated when there is evidence of a failure of the excretory powers of the kidney. The only death attributable to diodone in our series was ascribed to this cause.

C. J., R.I. 57352/46. Female, aged 40 years. In 1931 and 1937 this patient had two miscarriages and on each occasion suffered from toxæmia of pregnancy. After 1931 she developed headaches, which gradually became more frequent and severe. In 1937 she developed a sudden partial left hemiparesis, from which she recovered in a few weeks. In 1943 she began to suffer from attacks of unconsciousness, with twitching of the right side of the face. On admission, on May 15, 1946, she was mentally slow and had a mild right hemiparesis. The blood-pressure was 135/85 mm. Hg, the peripheral arteries appeared normal, and the heart was not enlarged. There was much albumin in the urine and the blood-urea was 54 mg./100 c.c. Plain radiographs of the skull suggested increased vascularity of the left frontal region and a meningioma was suspected. On May 20 open angiography was performed and a total of 120 c.c. of 35 per cent diodone was injected. There were no immediate reactions. A day later she complained of pain in the loins and gradually developed anuria. The blood-urea slowly rose to 104 mg. per cent, and she died on May 25. Autopsy revealed chronic nephritis and a subacute bacterial endocarditis. There was evidence of old yellow infarcts of the spleen and brain, with a firm white thrombus in the left middle cerebral artery.

This illustrates the danger of using diodone in cases of chronic nephritis. It is also likely that the thrombus of the left middle cerebral artery formed after the angiogram, as there was good filling of this vessel in the films.

From this review of our experience with diodone it is clear that it is safe provided that it is not used in patients with renal damage, gross hypertension, or an allergic history, and as a rule not more than 60 c.c. of 35 per cent diodone should be used.

RADIOGRAPHIC TECHNIQUE

We employ the Lysholm-Schönander skull table with a tube-film distance of 30·0 in. A fine-focus rotating-anode tube is used at 150 ma., 80–85 kv., with an exposure time of $\frac{1}{8}$ second, which is occasionally increased if the patient has a dense skull. Consistent with the demands of skull density and adequate contrast, the shortest possible exposure is used in order to give the sharpest image. It minimizes the effect of slight movement by the patient.

In the past longer exposures, even up to 1 second, have been used on the assumption that the contrast in all the vessels would be caught at some part of this exposure. Theoretically, the net result of such a long exposure may not be satisfactory. We may consider a length of vessel filled with contrast during the first $\frac{1}{2}$ second of the exposure, thus giving an adequate shadow. If during the ensuing $\frac{1}{2}$ second the circulation of the blood has moved the column of contrast onwards, the X rays will now penetrate in the first area to cancel out the previous shadow.

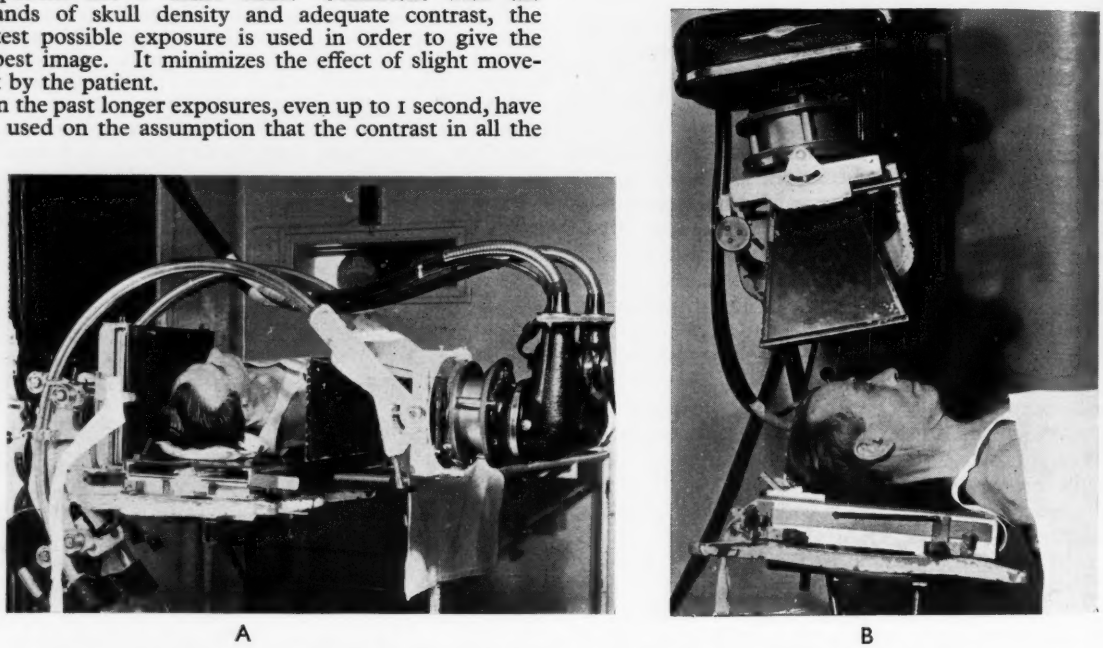
If the timing is correct so that the exposure is made when the vessels are filled, contrast effect is not lost by a short exposure with high kv. To attain good timing, experience, team work, and constant practice are essential.

The type of film required for the clearest definition for diagnosis should be hard, with good penetration, which is obtained by increasing the kv.

For routine work we use a cassette-changer which is a modification of the type described by Lindgren (1947). It provides for three films in the A.P. projection or in the lateral projection (*Fig.* 445), a separate injection of contrast medium being required for each. Films are taken at 0, 2, and 6 seconds, zero being approximately at the end of the injection. As Egas Moniz (1940) showed, these catch approximately the arterial phase, the capillary and early venous phase, and the late venous phase.

The apparent circulation time is influenced by variations in the technique, such as the quantity of contrast medium injected, and the time the injection takes. Engeset and Kvadsheim (1948) described an automatic timing apparatus fired by the syringe, but this does not overcome all the possible variations. Christophe and Honore (1947) described a more complicated apparatus which both injected and took films automatically. This apparatus is very elaborate; I have found that with the same assistant using the syringe a uniform standard can be obtained.

Recently this department has developed an apparatus which will take up to twenty-five exposures at $\frac{1}{2}$- or $\frac{2}{3}$-second intervals (Curtis, 1949). This enables finer details of the cerebral circulation to be studied and has demonstrated the need for multiple films, and also the



A B

FIG. 445.—Cassette-changer for routine 3-film angiography. A, Position for the lateral films. B, Position for the A.P. films; the vertical component has been removed to prevent it impingeing on the shoulder, and to permit the head to be brought well up on the film. For clarity the protective screens have been removed.

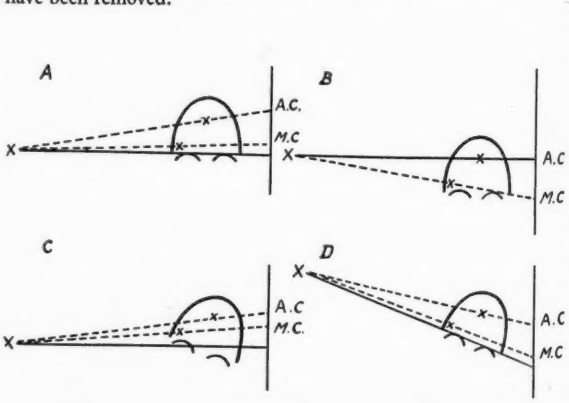


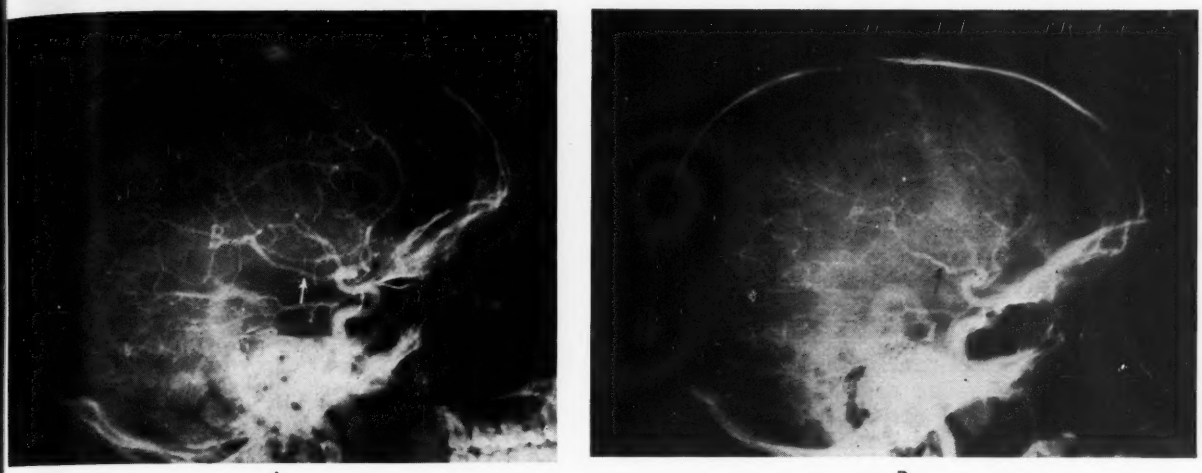
FIG. 446.—A, B, C, D, Factors introducing parallax in lateral projections:—

a. The relation of the level of the head to the central rays of the tube: With the Lysholm-Schönander table ordinarily the central rays of the tube are focused to the centre of the film. It is most satisfactory to have the central rays pass through the region of the pituitary fossa or in the plane of the orbital plates (A). Sometimes the physical characteristics of the patient prevent the head coming as far up as this, and the central rays will then pass through at a higher level (B). The middle cerebral artery (M.C.) will then be projected at a slightly lower level and may thus appear depressed. The orbital plates will be separated, thus simulating tilting of the head.

b. The relation of the sagittal plane of the head to the central rays of the tube: If this is strictly a right angle and the sagittal plane is parallel to the film (A), there is no distortion and the fixed points retain their true relation to one another on the image. If the head is tilted parallax is introduced. This is most important in the projection C, which throws the image of the middle cerebral up in relation to both the anterior cerebral and the skull outline. Tilting of the head in the opposite direction produces the opposite result. The relation of the sagittal plane to the plane of the film is of minor importance provided the sagittal plane is at right angles to the central ray of the tube (D). Although forelengthening of the image may be produced, the correct relation of fixed points in different planes is retained.

need on occasion to alter the timing of the three films of the routine method.

Positioning.—Accurate positioning of the head is essential because, with a short film-tube distance, serious errors of parallax may arise in the projection on to a flat surface of the cerebral vessels, which lie in many different planes. The angiographic diagnosis of expanding intracranial lesions depends to a large extent on the relative positions of one vessel or group of vessels to another (*Fig.* 446). It is in the relationship of the middle cerebral group to the carotid siphon and the anterior cerebral artery that this parallax attains its greatest importance. The effects of head tilting on the normal lateral arteriogram are shown in *Fig.* 447.



A B

FIG. 447.—The effect produced in a normal arteriogram by tilting the head relative to the tube. A, The sagittal plane of the head is at right angles to the central ray. Centring is at a higher level than the orbital plates and so these are separated. B, The head is tilted and the image of the middle cerebral (↑) is thrown upwards. The orbital plates are now superimposed by the divergent rays of the tube, owing to the high centring. If this superimposition of the orbital plates were accepted as the criterion of a correct lateral projection, the false position of the middle cerebral may not be recognized.

Lateral Projection.—The introduction by Lindgren (1947) of the vertical cassette holder, so that the lateral projection can be taken with the tube horizontal and the head vertical, has to a large extent overcome the distortion from parallax. Such distortion was more difficult to overcome by the older technique of rotating the head to one side, with the film horizontal and the tube in the vertical plane. This is illustrated by the following experience which happened in this department before we had a vertical cassette holder.

T. G., R.I. 70207/47. A male, aged 33 years, had suffered from intermittent headache and personality change during the previous year. Five days before admission there was a sudden onset of right-sided hemiparesis and aphasia. There was questionable early papillœdema, and no clinical evidence of cardiovascular disease. The left lateral arteriogram showed a Sylvian group apparently grossly elevated, with no filling of the anterior cerebral artery (*Fig.* 448). The right lateral arteriogram was normal and, as the left A.P. projection showed no filling of the anterior cerebral artery, it was not known whether there was any lateral displacement. The gross tilting of the head in the left lateral film was disregarded, and the diagnosis of a left temporal avascular tumour was made. On needling the left temporal lobe through a burr hole a capacious temporal horn was found and subsequent pneumo-encephalography showed a fairly gross degree of hydrocephalus due to cerebral atrophy, the cause of which remained undetermined.

The distortion by parallax of a middle cerebral group already diagonally stretched and elevated by a dilated temporal horn led to a faulty interpretation of the angiographic appearances.

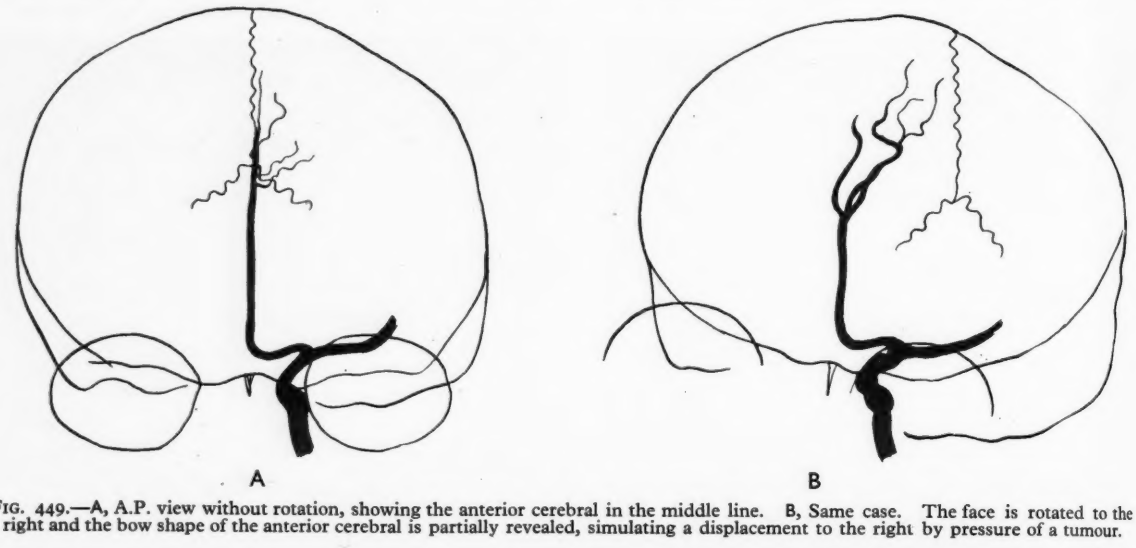
Anteroposterior Projection.—Owing to parallax, vessels running anteroposteriorly appear as a vertical line in this view. Rotation of the head tends to alter this. Because it is bow-shaped, the anterior cerebral artery may appear to be displaced when the head is rotated laterally (*Fig.* 449). With pathological displacement of the anterior cerebral the shape of the displacement may be altered by rotation (*Fig.* 450).

FIG. 448.—*Case* T. G., 70207/47. Line drawing of combined arteriogram and ventriculogram outlines. The wide separation of the outlines of the petrous temporal bones indicates the degree of tilting. This projection corresponds to *Fig.* 446 C. A mistaken diagnosis of a left temporal tumour was made on the high position of the middle cerebral group.

The most satisfactory pictures are obtained when there is careful exclusion of rotation, and the axis of the central rays of the tube is parallel to the orbitomeatal line. The head should be flexed so that the angle which the central ray makes with the plane of the film approaches a right angle. The important area of the carotid siphon and bifurcation is thus projected clear of the petrous

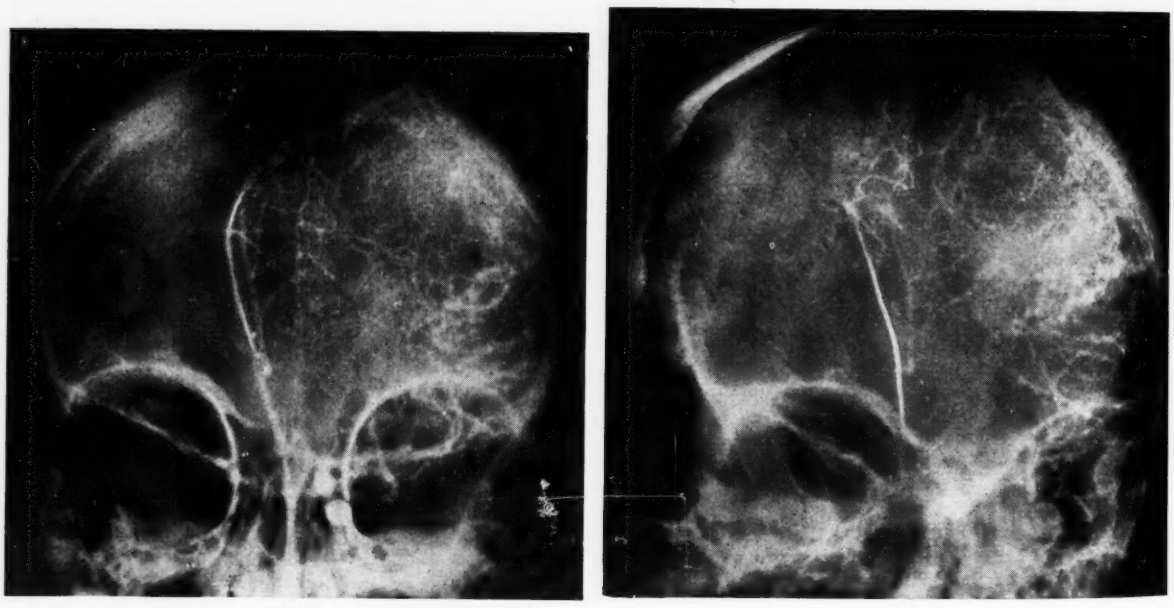
temporal bone. Variations of flexion and extension of the head and in the tube angle modify the angiographic picture obtained (*Fig.* 451).

In the A.P. projection described above, the region of the carotid siphon and early parts of the middle and anterior cerebral arteries are most clearly and accurately shown, but the middle cerebral vessels lying in the Sylvian group are greatly foreshortened. If these vessels need more detailed projection the tube angle should be increased to 25° or 30° (*see Fig.* 487).



A B

FIG. 449.—A, A.P. view without rotation, showing the anterior cerebral in the middle line. B, Same case. The face is rotated to the right and the bow shape of the anterior cerebral is partially revealed, simulating a displacement to the right by pressure of a tumour.



A B

FIG. 450.—A, A.P. view showing a curved displacement of the anterior cerebral to the right. This indicates a frontal tumour. B, The shape of this displacement is altered by rotation of the face to the left.

A B C

FIG. 451.—The effect on the internal carotid and its bifurcation of increasing the tube angle and thus increasing the obliquity of the image on the film. A, 10° tilt; B, 15° tilt; C, 25° tilt.

In the A.P. projection the terminal portion of the internal carotid artery may partly or wholly obscure an aneurysm arising on its posterior aspect, but an oblique

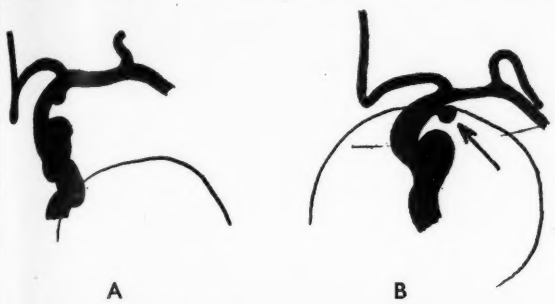


FIG. 452.—A method of demonstrating small aneurysms. A, A.P. projection with tube angle at 30°. The aneurysm is almost wholly obscured by the terminal part of the internal carotid. B, Oblique view through the orbit. The aneurysm is now clearly seen.

view through the orbit will show it (*Fig.* 452). For aneurysms of the intrapetrous portion of the internal carotid, Reid (1949) has recommended a basal A.P. view.

II. THE NORMAL ANGIOGRAM

THE NORMAL ARTERIOGRAM

The normal arteriogram and phlebogram have been described by many workers (Löhr and Jacobi, 1933; Egas Moniz, 1934; Fischer, 1938; Engeset, 1944; and others), but less attention has been paid to the variations of the normal pattern. A close knowledge of these variations is essential in the diagnosis of pathological lesions, particularly when the changes in the cerebral blood-vessels are not gross.

The findings here recorded are the result of the study of 78 normal angiograms from 59 patients of our series of 453 done by the routine 3-film method, and 16 normals done by serial angiography (Curtis, 1949). The diagnosis of normality was confirmed by cerebral air studies in the majority. A few cases of hydrocephalus have also been used to illustrate certain anatomical variations not due to the hydrocephalus. Fischer's classification (1938) of the vessels is the most convenient nomenclature to use and will be followed in this paper (*Fig.* 453).

A. LATERAL PROJECTION

Internal Carotid Artery.—The internal carotid artery enters the cranium beside the sella, pursues a curved course resembling a horizontal U opened posteriorly, and terminates by turning upwards. This was called by Egas Moniz the carotid siphon. One of its terminal branches, the anterior cerebral, passes medially, and the other, the middle cerebral,

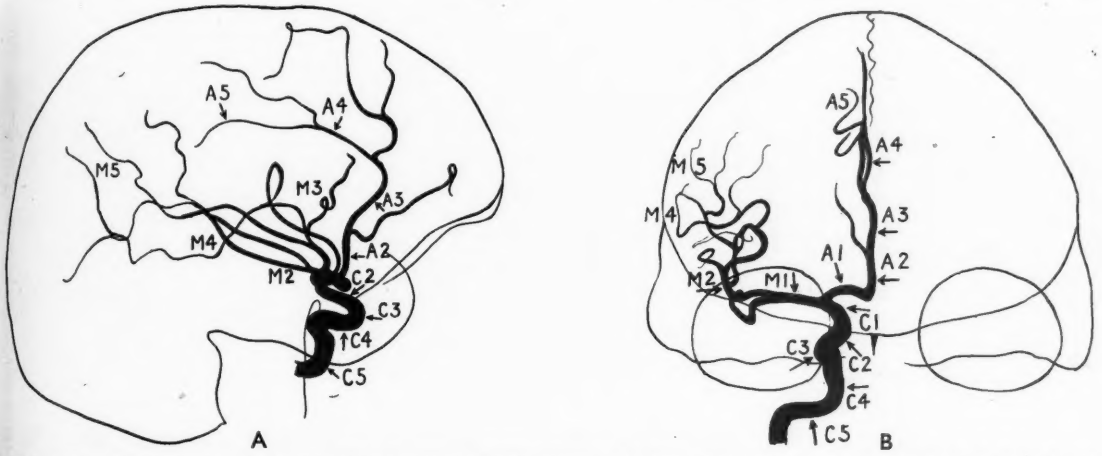


FIG. 453.—Fischer's method of classifying the internal carotid artery and its branches. A, Lateral projection. B, A.P. projection. C1–5 is the internal carotid artery, M1–5 the middle cerebral, and A1–5 the anterior cerebral.

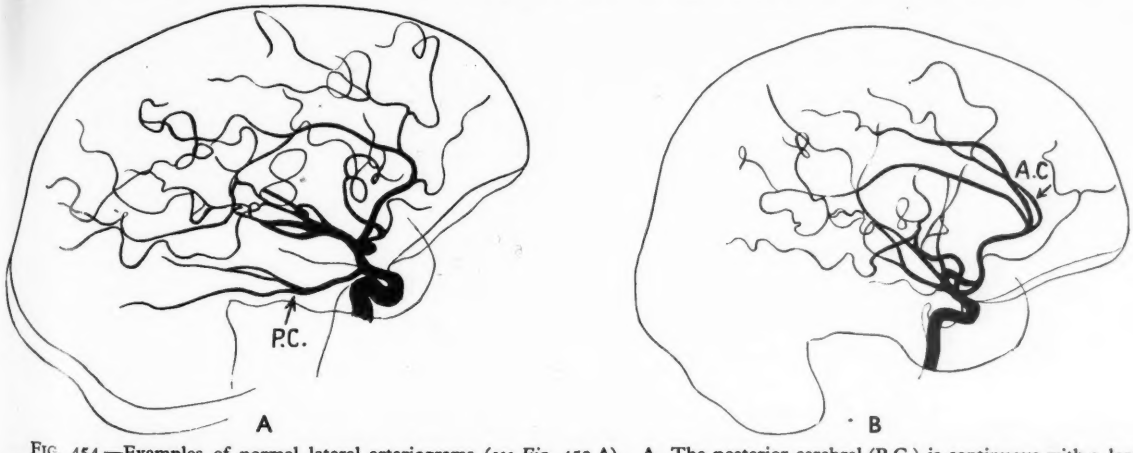


FIG. 454.—Examples of normal lateral arteriograms (*see Fig.* 453 A). A, The posterior cerebral (P.C.) is continuous with a large posterior communicating artery. B, Both anterior cerebral arteries (A.C.) are filled and pursue different courses. This appearance was not produced by divergent X rays.

curls forwards and laterally and then backwards and upwards in the Sylvian fissure (*Fig.* 454).

1. *Carotid Siphon.*—The width of the siphon, that is to say the distance between its two limbs, has

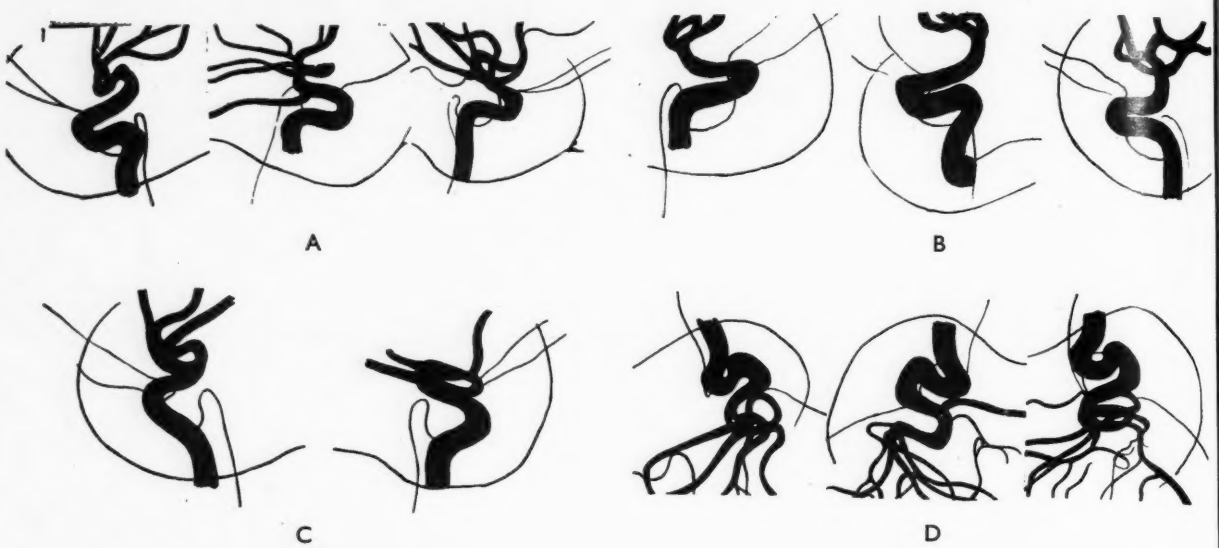


FIG. 455.—Illustrating variations in the normal carotid siphon. A, The most usual type. B, Flattened or squashed. Note that the middle cerebral group is at a high level. C, Opened out. D, The coiled type. E, Different appearances in the two sides of the one patient.

been described as being 1·0 cm. In our series it varied from 0·5 to 1·3 cm., with an average width of 0·9 cm. In normal subjects four types of siphon were seen :—

a. The most common (40 cases) is what might be called the normal U shape (*Fig.* 455 A).
b. In the second type (13 cases) the limbs of the U appeared flattened or squashed (*Fig.* 455 B).
c. In the third type (8 cases) the limbs of the U appeared to be open (*Fig.* 455 C). This type was found to be particularly common in

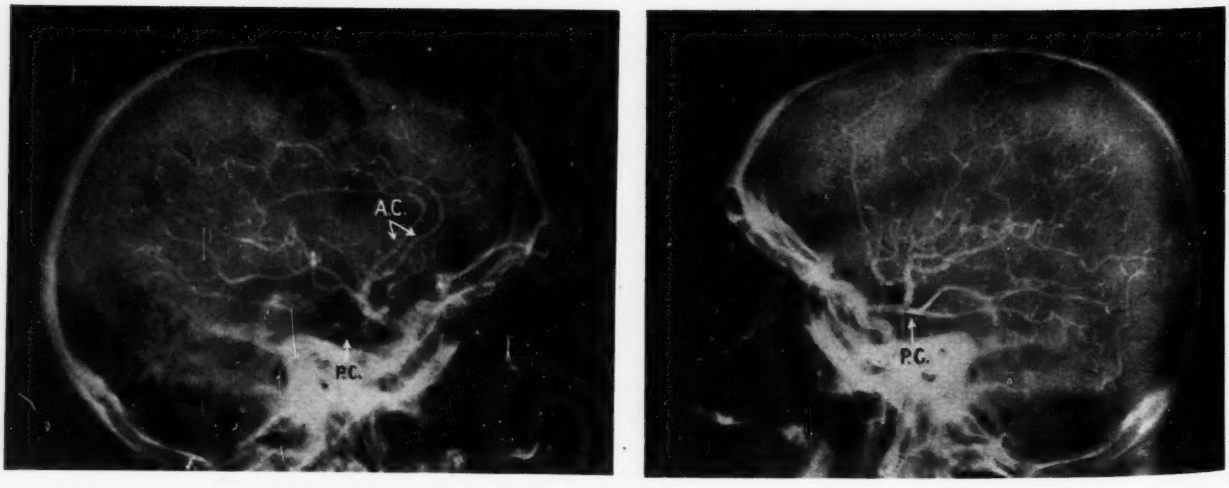


FIG. 456.—Right and left normal arteriograms in the same patient. A, The small curved posterior communicating artery (P.C.) is seen ; it is kinked at its site of entrance to the posterior cerebral. Both anterior cerebral arteries (A.C.) are filled and appear to arise from a common trunk. B, The posterior communicating (P.C.) is large and passes directly into the posterior cerebral which divides early into two large branches. On this side there is no filling of the anterior cerebral.

children : in 6 of 8 children the siphon showed this opened-out appearance. This type of siphon may be called the ' infantile ' type.

d. In the fourth type (11 cases) the siphon was coiled and resembled an S rather than a U (*Fig.* 455 D).

In addition, among 23 normal cases in which bilateral angiograms were done, there were 11 in which the shape of the siphon differed on the two sides (*Fig.* 455 E).

2. *Branches of the Siphon.*—

a. Ophthalmic artery : This arises constantly from the upper surface of the upper limb (C2 of Fischer, *Fig.* 453), and proceeds forwards into the orbit. It

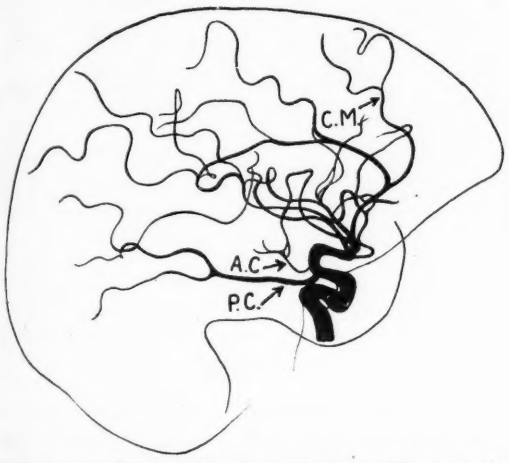


FIG. 457.—Normal lateral arteriogram. The posterior communicating (P.C.) is large and continuous with the posterior cerebral which forms its main branches at its usual site. The anterior choroidal (A.C.) is lying with its normal curve just above the posterior communicating. Marginal callosal artery (C.M.).

is almost always seen (*Figs.* 447 A, 468 A) ; sometimes the bony markings of the orbit obscure it. Marx (1949) has demonstrated angiographically in a case of internal carotid thrombosis that it may provide a collateral circulation from the external to the internal carotid artery. This fact had previously been inferred from observations that ligation of the internal carotid proximal and distal to the ophthalmic artery, as for carotico-cavernous aneurysm, usually does not produce blindness in the corresponding eye (Dandy, 1944).

b. Posterior communicating artery : When visible this artery arises from the posterior distal aspect of the upper limb of the carotid siphon, where it turns upwards at the junction of C2 and C1. It passes backwards. Its site of origin is remarkably constant, but its size and course vary. There is a large type (*Figs.* 456 B, 457) in which the primitive origin of the posterior cerebral from the internal carotid persists, and the posterior cerebral and posterior communicating are one continuous vessel. In its more usual form the posterior communicating is thinner and describes a curve, with convexity downwards, to run into the posterior cerebral (*Fig.* 456 A).

It will be convenient to describe now the appearance of this artery in the A.P. view. It occupies the space between the anterior and middle cerebral

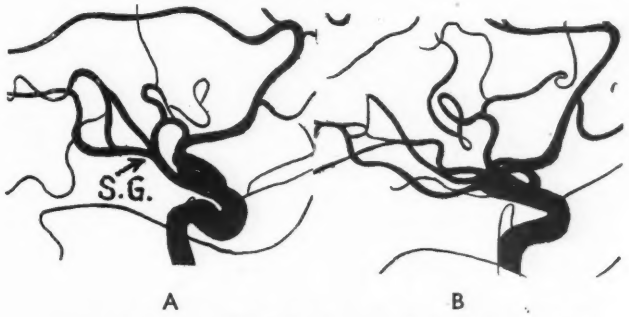


FIG. 458.—A, B, The Sylvian group (S.G.) lying at a low level. B also shows apparent downward displacement of these vessels.

arteries and pursues an S-shaped course, the first curve facing convexly inwards, and the second outwards (*see Fig.* 468 B). This appearance is fairly constant (Engeset, 1948, b).

With the routine 3-film method the artery is displayed in 25 to 30 per cent of cases, with serial angiograms in 65 to 70 per cent of cases.

c. Anterior choroidal artery : This artery arises from the internal carotid immediately distal to the posterior communicating and can be recognized fairly constantly (*Fig.* 457) as a thin vessel passing backwards with a slight downward curve, immediately above the posterior communicating.

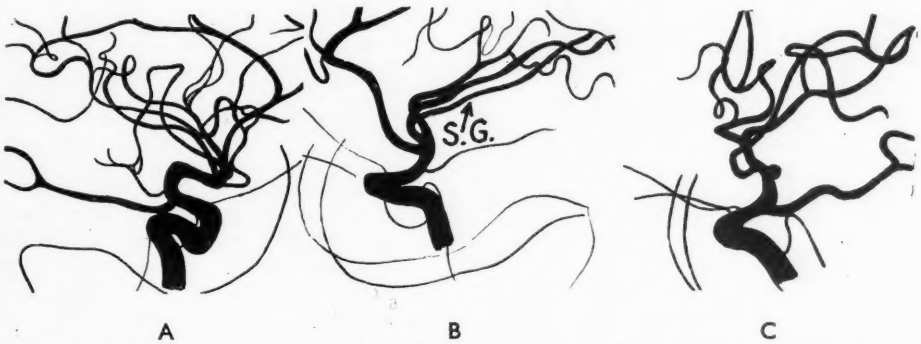


FIG. 459.—A, B, C, The Sylvian group (S.G.) at a high level, but nevertheless normal since it does not show an arched upward displacement, nor are the vessels stretched. A, With the double siphon described by Egas Moniz. B, With a flattened siphon. There is slight tilting of the head.

3. *Middle Cerebral Artery.*—This artery arises from the termination of the internal carotid and enters the Sylvian fissure where, after a variable

distance, it divides into two primary branches—the artery of the angular gyrus and the posterior temporal artery. Other branches, including the pre-Rolandic and the posterior parietal, arise from these. After passing forwards and laterally to a variable extent

FIG. 460.—Examples of the Sylvian group (S.G.) lying at different levels on the two sides of the same patient.

the middle cerebral and its main branches curve upwards and backwards. This Sylvian group of vessels usually runs parallel to the upper limb of the siphon and in a plane about 1·0 cm. above it (*Fig.* 454 A). In 78 normal angiograms this distance varied from nothing (*Fig.* 458) to 2·0 cm. (*Fig.* 459), the average being 0·9 cm. In some cases there was a marked

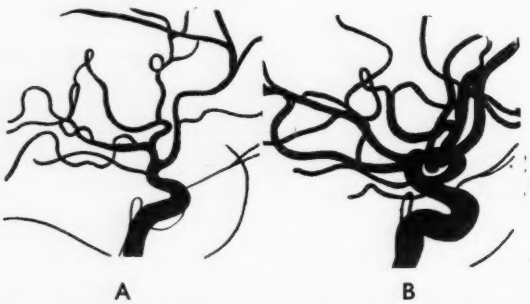


FIG. 462.—A, B, Examples of the Sylvian group showing a downward curve. In B the vessels also run at a low level.

difference between the two sides (*Fig.* 460). Where the distance is great it may be associated with a flat siphon (*Fig.* 459 B). In estimating this 'parallel displacement', as Egas Moniz called it, the distortion produced by tilting of the head should be borne in mind (*Figs.* 446–448).

In their course along the Sylvian fissure the Sylvian group of arteries usually describe a series of gentle undulating curves, the predominant direction being backwards and slightly upwards. Normal variations include stronger curves with convexity upwards (*Fig.* 461) or downwards (*Fig.* 462), and these may simulate pathological displacement from below or above. However, in pathological displacements the vessels appear stretched and all the branches take the same course (*see Fig.* 476 B).

The *pre-Rolandic artery* most frequently leaves the Sylvian group early, emerges on the surface of the convexity of the hemisphere, and supplies the frontal convolutions. It usually passes forwards,

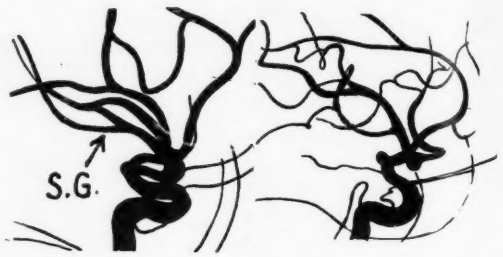


FIG. 461.—A, B, Apparent upward displacement of the Sylvian group (S.G.). A, Shows a local upward curve at M2. B, The main branch takes an upward curve while the smaller branch runs at a lower level.

then upwards (*Fig.* 463 A, B), and divides to give the appearance of a candelabra. In one case it came out of the Sylvian fissure rather late, but then proceeded normally upward (*Fig.* 463 C). It is very variable in size, direction and branching, but in our series there were no examples where its main branch continued backwards parallel with the Sylvian group.

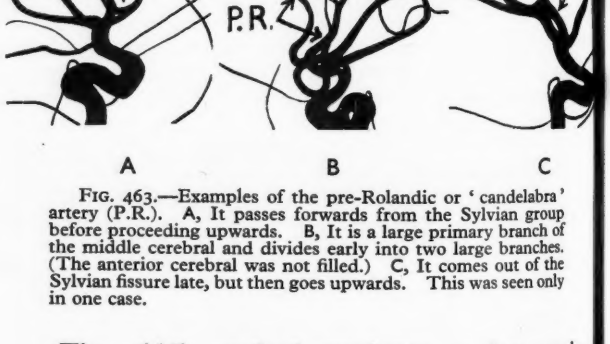


FIG. 463.—Examples of the pre-Rolandic or 'candelabra' artery (P.R.). A, It passes forwards from the Sylvian group before proceeding upwards. B, It is a large primary branch of the middle cerebral and divides early into two large branches. (The anterior cerebral was not filled.) C, It comes out of the Sylvian fissure late, but then goes upwards. This was seen only in one case.

The middle cerebral terminates as three main branches which radiate out from the Sylvian fissure at its posterior end. They are the posterior parietal artery, the artery of the angular gyrus, and the posterior temporal artery. There is no constancy in their course, and frequently they cannot be individually recognized; there may even be multiple branches. In this region pathological displacements cannot be diagnosed on individual variations, but only by mass displacements of these vessels.

4. *The Anterior Cerebral Artery.*—This artery proceeds medially and slightly forwards from the internal carotid, passing above the optic nerve or chiasm. Its proximal part (A1, *see Fig.* 453 B) cannot normally be distinguished in the lateral projection.

On reaching the middle line it proceeds forwards and upwards around the genu, and then follows the body of the corpus callosum back to the splenium. Its main branches are the frontopolar and the marginal callosal; after these branches are given off it continues above the corpus callosum as the pericallosal artery.

The anatomical variations of this vessel have been well described by Almeida Lima (1950). The following are important in arteriographic diagnosis when considering the presence or absence of collateral circulation through the anterior part of the circle of Willis with a view to carotid ligation: (*a*) The anterior communicating artery is absent; (*b*) Both anterior cerebral arteries are supplied mainly from one internal carotid with only a rudimentary vessel from the other; (*c*) Both anterior cerebral arteries are supplied entirely from one internal carotid artery and there is no connexion with the other internal carotid (*Fig.* 464); (*d*) There is only a single anterior cerebral artery, supplied from one or other or both internal carotid arteries. Because of these variations one must be most cautious in diagnosing pathological blockage of the first part of the anterior cerebral artery.

The ascending parts (A2 and A3, *see Fig.* 453) of the artery pass obliquely forwards and upwards in the middle line and show two curves which vary considerably (*Figs.* 454, 465): the first curve is convex forwards and the second convex backwards. The genu of the artery usually shows an elegant curve (*Fig.* 454) which conforms to the genu of the corpus callosum, but there are variations. It may be angulated (*Fig.* 466 D) or prow-shaped (*Fig.* 466 E). It may be apparently squashed, as a result of a deep curve at A3 (*Fig.* 466 C) or A4 (*Fig.* 466 A, B). It may appear widened if the usual curve of A3 is absent (*Fig.* 466 F), or if it itself has a double curve *Fig.* 466 G).

The relation of the pericallosal to the marginal callosal artery is important because the diagnosis of expanding parasaggital lesions may depend largely on the recognition of the displacement of these vessels. The usual appearance is seen in *Fig.* 454 B. As a common variation two or more branches take the place of the marginal callosal (*Figs.* 467 A, B, C).

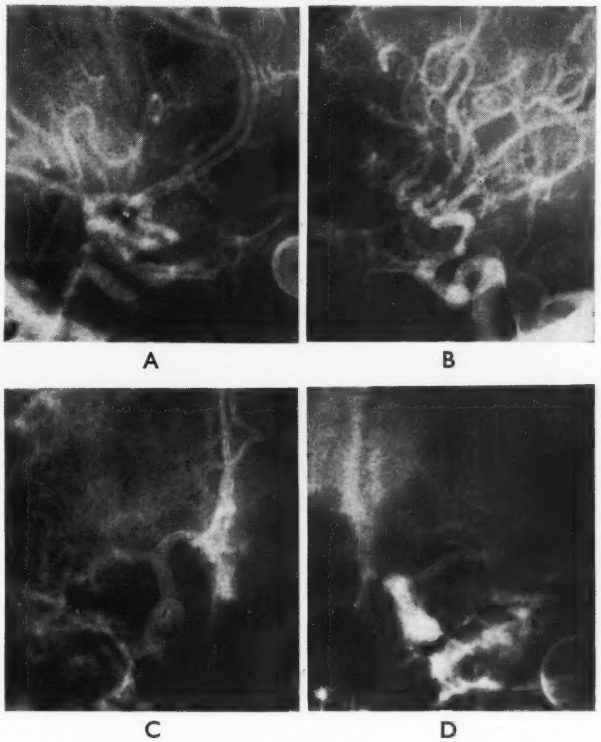


FIG. 464.—A, B, Lateral, and C, D, anteroposterior views on both sides of the same patient, showing both anterior cerebral arteries arising from the right internal carotid artery.

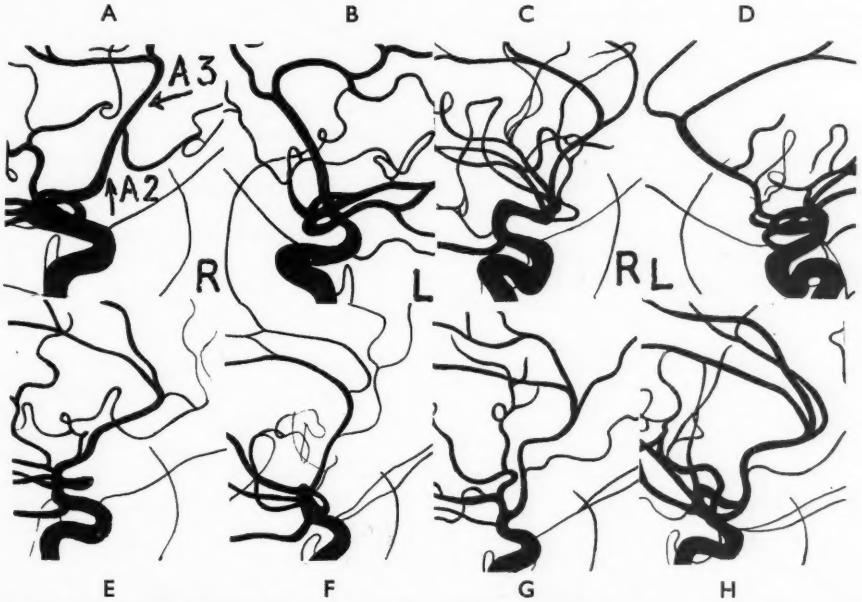


FIG. 465.—Variations of the course of A2 and A3 of the anterior cerebral. A–D show the differences in the two sides in two patients. A, The first curve is exaggerated and the second curve almost absent; B, There is only one gentle slightly concave curve; C, The first curve is almost absent; D, A2 only is curved. E, F, Both curves are almost absent. G, There is a deep second curve giving a squashed appearance to the genu. H, Both curves are deep.

Other variations depend on the pericallosal or marginal callosal, or both, departing from their usual course along the fissures bounding the cingulate

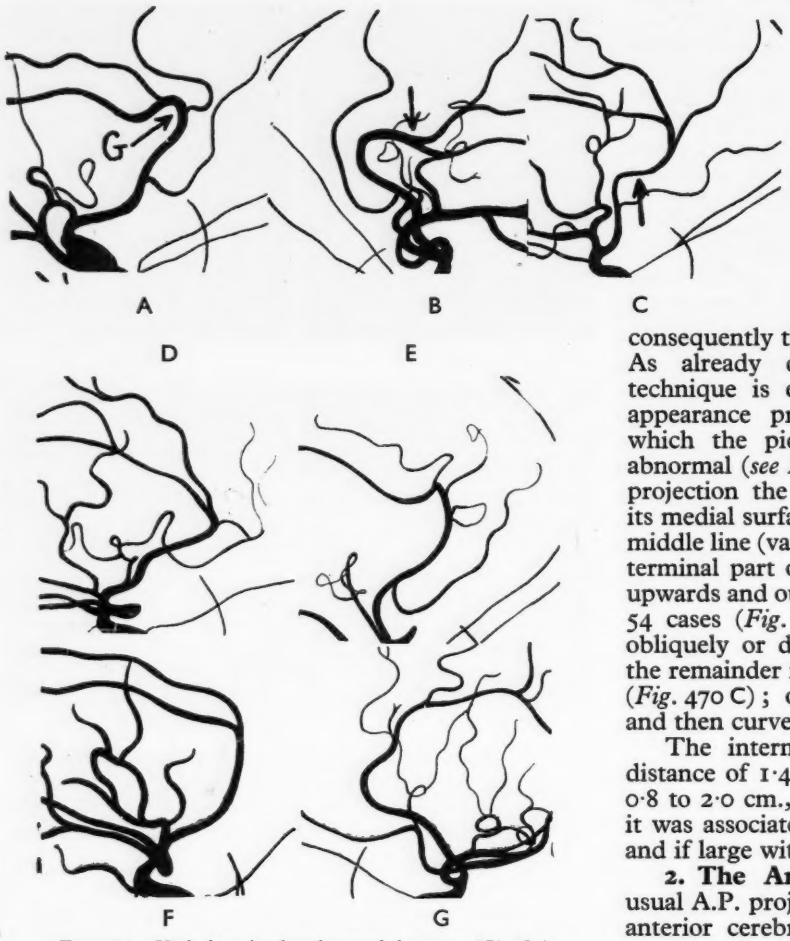


FIG. 466.—Variations in the shape of the genu (G) of the anterior cerebral artery. A, B, C, The squashed appearance is caused by either a downward curve of A4 (B ↓) or an upward curve of A3 (C ↑); D, Angulated; E, Prow-shaped; F, G, Widened.

gyrus. As a result the two vessels may be widely separated, suggesting a parasagittal tumour where in fact none exists (*Fig.* 467 B, C). In some cases the marginal callosal may be the main vessel, and if the pericallosal is poorly filled a false impression of hydrocephalus may be obtained.

B. ANTEROPOSTERIOR PROJECTION

With this projection the parts M1 of the middle cerebral and A1 of the anterior cerebral (*see Fig.* 453), which were obscured in the lateral projection, are now clearly seen (*Fig.* 468). Of the middle line course of the anterior cerebral A2 and A3 are well shown and its more posterior portion (A4 and A5) is greatly foreshortened (*Fig.* 468). Similarly the parts M2, 3, and 4 of the middle cerebral are also foreshortened.

1. The Sellar and Suprasellar Region.—In this region space-occupying lesions are small, and consequently they produce only small displacements. As already described, a standard radiographic technique is essential, otherwise the variations in appearance produced by the different angles at which the picture is taken may be regarded as abnormal (*see Fig.* 451). With the standard type of projection the carotid siphon appears end-on, and its medial surface lies on an average 0·8 cm. from the middle line (variations 0·5 to 1·3 cm., 54 cases). The terminal part of the internal carotid, C1, proceeded upwards and outwards in a gentle curve in 26 of these 54 cases (*Fig.* 470 A). In 15 it proceeded more obliquely or diagonally outwards (*Fig.* 470 B). In the remainder it proceeded almost vertically upwards (*Fig.* 470 C); or at first passed medially and upwards and then curved sharply outwards (*Fig.* 468 A).

The internal carotid bifurcated at an average distance of 1·4 cm. from the middle line (variations 0·8 to 2·0 cm., 54 cases). If the distance was small it was associated with the more vertical type of C1, and if large with the oblique or diagonal type.

2. The Anterior Cerebral Artery.—In the usual A.P. projection the parts A1, A2 and A3 of the anterior cerebral are most clearly seen, and those portions distal to the genu of the corpus callosum (A4 and A5) are grossly foreshortened (*Figs.* 453, 468). In a half-axial projection more is seen of the marginal and pericallosal portions of the anterior cerebral arteries.

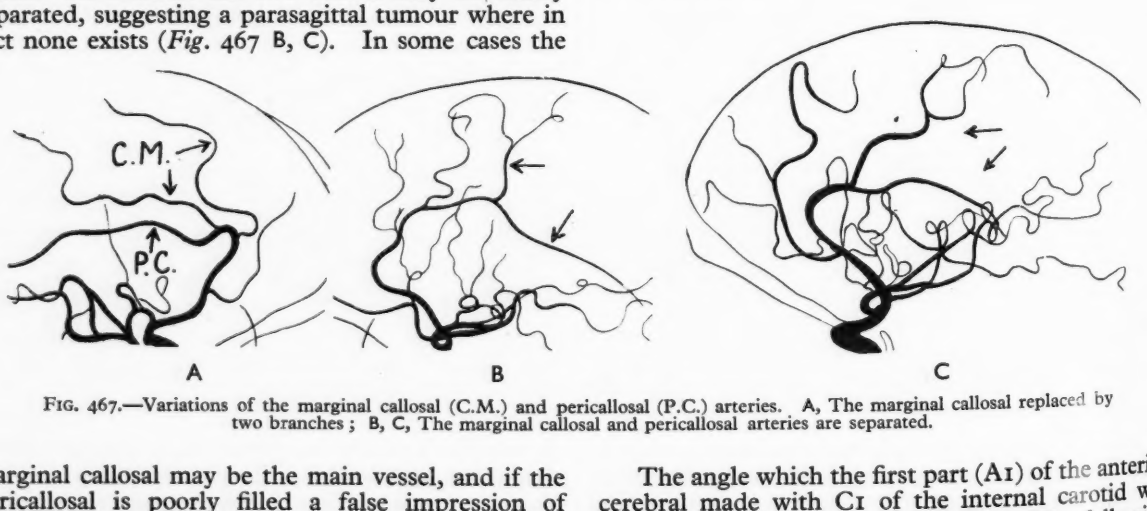


FIG. 467.—Variations of the marginal callosal (C.M.) and pericallosal (P.C.) arteries. A, The marginal callosal replaced by two branches; B, C, The marginal callosal and pericallosal arteries are separated.

The angle which the first part (A1) of the anterior cerebral made with C1 of the internal carotid was less than 90° in 48 out of 54 cases. The following

variations of the course of A1 were found: (*a*) The most common appearance (27 cases) was a horizontal straight line (*Fig.* 470 C); (*b*) The second type (15 cases) was a slight curve (convexity upwards) with the carotid bifurcation and the junction of A1 and A2 in the same horizontal plane (*Fig.* 470 A).

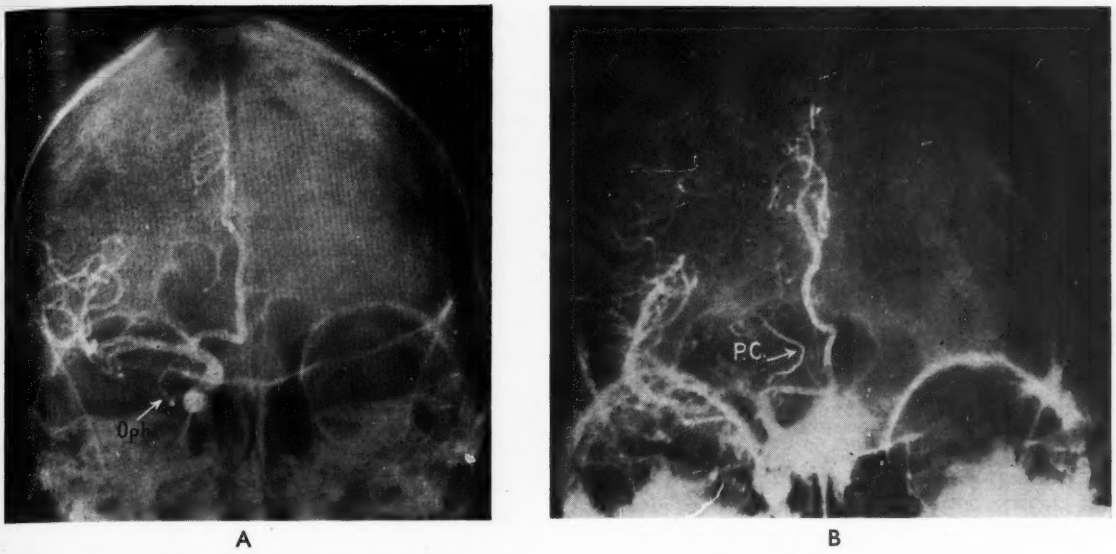


FIG. 468.—Normal A.P. arteriograms (*see Fig.* 453 B). A, A2 and A3 keep to the middle line and there is a slight bend in the artery at the genu. The middle cerebral branches at its usual site. The ophthalmic artery (Oph.) is seen. B, There is no general displacement of the anterior cerebral from the middle line, but its course is somewhat irregular. This is accounted for by its variable course in the sulci on the medial surface of the hemisphere. The middle cerebral runs in its usual course. The posterior cerebral artery (P.C.) can be seen with its two curves. The inset diagram shows the manner in which the anterior cerebral artery is projected on the film.

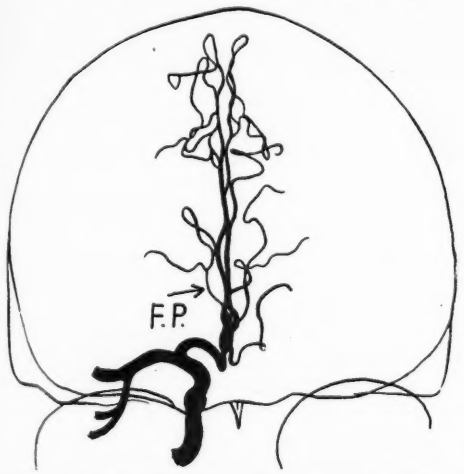


FIG. 469.—A.P. view of the siphon region and anterior cerebral arteries, both of which are filled. There is no rotation and the orbital plates and petrous temporal bones are superimposed by the head being flexed. The terminal portion of the internal carotid (C1) curves obliquely upwards and outwards. The first part of the anterior cerebral (A1) runs in a curve convexly upwards and the junction of A1 and A2, where it changes direction to pass upward, is at a lower level than usual. The vertical parts of both anterior cerebral arteries show minor local variations in course. The frontopolar artery (F.P.) is seen.

In three of these cases the angle between the internal carotid and A1 was 90°; (*c*) In the third type (5 cases) the junction of A1 and A2 was at a lower level than the carotid bifurcation (*Fig.* 469). Two of these cases had an exaggerated upward curve and the angle between the internal carotid and A1 was slightly greater than 90°; (*d*) In 4 cases the junction of A1 and A2 was at a slightly higher level than the carotid bifurcation (*Fig.* 470 B). In 3 of these A1 appeared straight and the angle it made with the internal carotid was less than 90°. In 1 case this angle was 90° and the anterior cerebral was curved at the junction of A1 and A2 (*Fig.* 451). In 5 of the 11 bilateral cases there was a difference in the appearance of the two sides (*Fig.* 471).

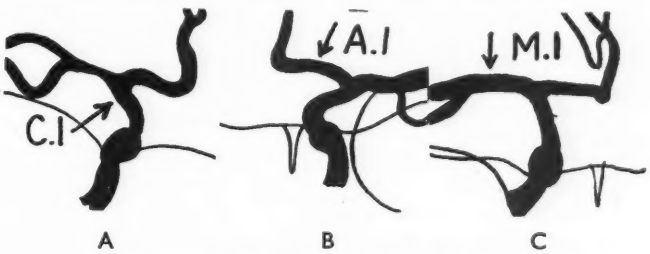


FIG. 470.—Variations of the terminal part of the internal carotid (C1) and the first parts of the anterior cerebral (A1) and middle cerebral (M1) arteries. A, C1 goes upwards and outwards in a slight curve. A1 proceeds medially with a slight horizontal S curve. B, C1 proceeds very obliquely upwards and outwards. A1 has a slight upward curve. C, C1 is almost vertical. A1 is horizontal.

The junction of A1 and A2 is strictly in the middle line and here there is an abrupt bend (*Fig.* 468). Rarely it may be a more gentle curve (*Fig.* 451).

In the majority of cases A2 and A3 remain in the middle line and are vertically straight (*Figs.* 468 A, 471 A). But there are numerous variations which

take the form of small localized curves to one or other side (*Figs.* 468 B, 472). These probably correspond to gyri projecting across the middle line from one or other side, or to variations of the course

FIG. 471.—Variations of the internal carotid and its branches on the two sides of the same patient. A: *R*, The siphon appears coiled. C1 is fairly oblique and A1 is curved; *L*, C1 is more vertical but curved, A1 is almost horizontal. On both sides A2 and A3 are straight. B: *R*, C1 is fairly oblique but with a sharp bend, A1 has a slight horizontal S curve; *L*, C1 has a pronounced curve convex inwards, A1 has a pronounced horizontal S curve. On both sides A2 and A3 have a slightly irregular course.

of the vessel in a sulcus, and must not be confused with a general displacement of the anterior cerebral artery.

Generally there are two sites where there is obvious branching of the main artery. The first, or lower, marks the origin of the frontopolar artery which can be seen proceeding upwards and laterally in an oblique direction (*Fig.* 469). The second is in the region of the genu where the marginal and pericallosal branches arise. There may be a small change in direction in the line of the artery at both these points (*Fig.* 468 A).

3. The Middle Cerebral Artery.—At the bifurcation of the internal carotid the middle cerebral

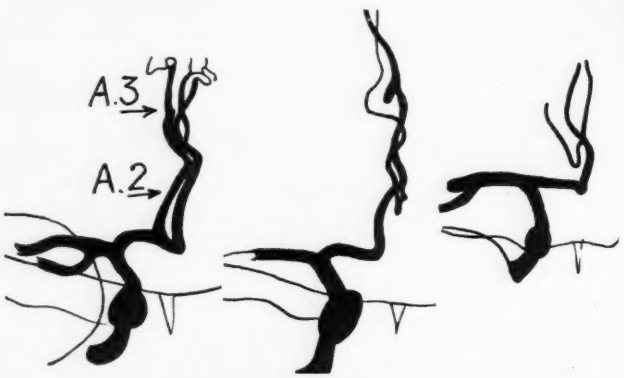


FIG. 472.—Variations of the anterior cerebral at A2 and A3. Despite localized departures, however, there is a general adherence to the middle line, which is indicated by the prow of the vomer.

proceeds laterally, lying horizontally. Its course may be straight, slightly curved with convexity upwards, or slightly S-shaped (*Fig.* 468). At a distance approximately two-thirds to three-quarters of the way from the middle line to the lateral border of the inner table of the skull, the middle cerebral changes its direction fairly abruptly and appears to proceed upwards. The change of direction may be a more gentle curve, but M1 is still horizontal in its general course.

The primary branching usually takes place in the outer part of the horizontal course of the artery (*Fig.* 468 A), but may be earlier (*Fig.* 472). Usually there are only two main branches, but occasionally three (*Fig.* 469).

THE NORMAL PHLEBOGRAM

Both the superficial and deep veins of the cerebral hemispheres are always visualized in the normal case. The superficial veins can generally be seen draining to three sinuses: (1) ascending cortical veins passing to the superior longitudinal sinus; (2) superficial frontal and temporal veins to the sphenoparietal sinus; and (3) superficial occipital and posterior temporal veins to the transverse sinus. There is no constant pattern; the site and filling of these superficial veins is too variable for them to be of diagnostic value except when they are grossly stretched in a

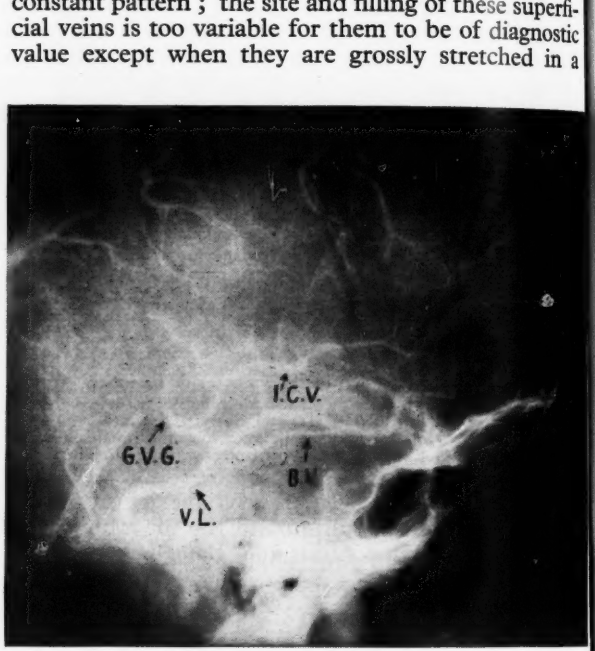


FIG. 473.—Normal phlebogram shown by rapid serial angiography. V.L., inferior anastomotic vein of Labbé. I.C.V., internal cerebral vein. G.V.G., great vein of Galen. B.V., basilar vein of Rosenthal.

wide arc and have lost all resemblance to their normal slightly wavy pattern.

Three large veins can be occasionally distinguished. The first is the superior anastomotic vein of Trollard, which, when present, courses upwards and backwards from the region of the Sylvian point to the superior longitudinal sinus. The second is the inferior anastomotic vein of Labbé which passes backwards and downwards from the region of the Sylvian point to the transverse sinus (*Fig.* 473). The third is the Sylvian vein which passes forwards from the same region to the sphenoparietal sinus which follows the sphenoidal wing; but this vein is frequently replaced by a leash of small veins. These three large veins may be seen to anastomose with one another about the Sylvian point.

The deep veins are more constant in position. The internal cerebral vein is frequently seen in the routine films and always in rapid serial films (*Fig.* 473). Its gentle curve, concavity downwards, outlines the roof of the third ventricle accurately. At its anterior end it curls back on itself and usually the

tributaries which unite to form it can be faintly seen. The site of this curl marks the position of the foramen of Monro which is usually directly above the posterior clinoid process. In the A.P. projection the great cerebral vein (of Galen) is seen end-on as a blob of contrast which is strictly in the middle line. It may be displaced laterally by tumours of the hemisphere and this may be helpful, particularly with posterior tumours, which may not cause a lateral displacement of the anterior cerebral artery. If the head is slightly rotated the curve of the internal cerebral vein is partly revealed.

The place where the posterior downward curve of the internal cerebral vein turns upward marks the beginning of the great vein of Galen (*Fig.* 473). At this site a smaller vein is sometimes seen joining the internal cerebral vein from below. This is the basilar vein of Rosenthal, which passes straight back on the inferomedial surface of the temporal lobe to help form the great vein of Galen. The great vein of Galen starts immediately above the pineal gland, and Egas Moniz (1941) pointed out that it and the posterior end of the internal cerebral vein may be elevated in pinealomas.

The great vein of Galen curves upwards slightly to join the inferior longitudinal sinus at approximately a right angle. This sinus follows the curve of the inferior border of the falx backwards and downwards, but it is generally not well seen. The U formed by the inferior longitudinal sinus, great vein of Galen, and internal cerebral vein outline the posterior part of the corpus callosum.

Egas Moniz was the first to show that the inferior longitudinal sinus does not change direction when it passes into the straight sinus, but continues in the same straight line.

THE CEREBRAL CIRCULATION

Overflow Filling.—Since the work of Kramer (1912) it has been considered that, despite the presence of the circle of Willis, each internal carotid artery supplies blood only to the anterior and middle cerebral arteries that branch from it, and that the vertebral arteries supply the posterior fossa and posterior cerebral arteries. However, Egas Moniz (1934) found by angiography that the internal carotid artery supplied the posterior cerebral in 23 per cent cases; some later workers raised this figure to 30 per cent (Engeset, 1948, b). In 226 carotid arteriograms examined from our material 28 per cent of posterior cerebrals filled.

With rapid serial angiography we have seen that a much larger percentage of posterior cerebral arteries filled with diodone from the internal carotid. Of 16 normals 11 showed filling (69 per cent), and of the whole series of 42 cases 22 showed filling (55 per cent). In 2 of the normals there was distinct retrograde filling of the basilar and anterior superior cerebellar arteries (Curtis, 1949). This difference from previous findings is explained by the fact that, in a considerable proportion of cases, overflow filling shows only at an early stage of arterial filling and has faded by the time of the usual routine arteriographic exposure.

Double filling of the anterior cerebral artery also occurs (*Fig.* 469). In rapid serial angiograms 10 of 16 normals (63 per cent) showed double filling of the anterior cerebral, and in the whole series of 42, 21 (50 per cent) showed double filling.

It is not suggested that this overflow is the usual or constant state of affairs. But, provided the necessary anastomotic channels are patent, overflow will be determined by the pressure gradient in the circle of Willis at any instant and this may be variable, being altered by factors in both the carotid and vertebral systems.

The Venous Circulation.—With rapid serial angiography it has been established in 16 normal cases that diodone can be distinguished in the cerebral veins from 2·5 to 3·5 seconds from the time of its entry into the internal carotid in the neck. The interval of time before the last signs of diodone disappear from the veins is more variable—varying from 6 seconds to over 12 seconds. We know two factors which influence this: They are the rate of injection and the quantity of diodone injected. A slower rate or an increased quantity prolong the period of venous circulation. It is possible that other factors such as blood-pressure, intracranial pressure, and respiratory excursion have an effect.

The Order of Venous Filling is as follows. The deep cerebral veins (almost always the internal cerebral vein), and certain superficial veins around the anterior part of the temporal lobe and Sylvian point, are the first to be seen. Then the diodone appears in the superficial ascending veins, and generally the last to be seen are the more posterior veins. In most cases diodone disappears from the deep veins sooner than from the superficial veins; and the last veins to be seen are those situated posteriorly. It would appear that this order is largely dependent on the distance the diodone has to travel through the arteries and capillaries before reaching the veins.

III. ANGIOGRAPHIC FEATURES OF INTRACRANIAL TUMOURS

GENERAL CONSIDERATIONS

No attempt has been made to describe the angiographic appearances in vascular diseases such as cerebral aneurysm, angiomatous malformation, thrombosis of the carotid and its branches, and so on; it will be readily understood, however, that these lesions play a large part in the daily angiographic work, and that, from the practical point of view, when dealing with the diagnosis of suspected intracranial tumours by angiography, these lesions must always be considered. The same applies to subdural hæmatoma, a lesion which can be accurately displayed by carotid angiography.

Intracranial tumours exhibit characteristics of growth which are of angiographic importance. These are: (1) Infiltration of brain substance; (2) Centrifugal growth of a tumour mass with consequent displacement of adjacent brain and vessels; (3) Further increase in total bulk of tissue from œdema of the brain, with further displacement of brain tissue and vessels, not only near the tumour but also in more distant parts; (4) Cyst formation within or around the tumour; (5) Necrosis of the tumour; (6) Hypertrophy of vessels supplying the tumour and the growth of pathological blood-vessels within it; (7) Blockage of the cerebrospinal fluid pathways which may produce ventricular dilatation.

These features may alter the pattern of the cerebral vascular tree and the angiographic diagnosis of intracranial tumours rests on these alterations, which may be evident in the following ways: (1) Displacement of vessels by the direct effect of the tumour, by the more remote effect of œdema of a hemisphere, or by ventricular dilatation; (2) Stretching of vessels by infiltration of brain substance by tumour tissue; (3) The presence of hypertrophied or pathological blood-vessels; (4) The absence of normal vessels; (5) Alterations in the order of filling of the vessels and in the circulation time.

The characteristics of growth, and consequently the angiographic features, vary with the pathological type of the tumour, its rate of growth, site, blood-supply, and vascular pattern. It must also be borne in mind that displacement of the brain across the middle line can only occur to any extent beneath the free edge of the falx cerebri. The falx is narrowest in its anterior half, which corresponds with the proximal part of the anterior cerebral artery. As a result, lateral displacement of the hemisphere, particularly the posterior half, will displace this vein even if there is no shift of the anterior cerebral.

From our material, after those with poor films have been excluded, 183 histologically verified

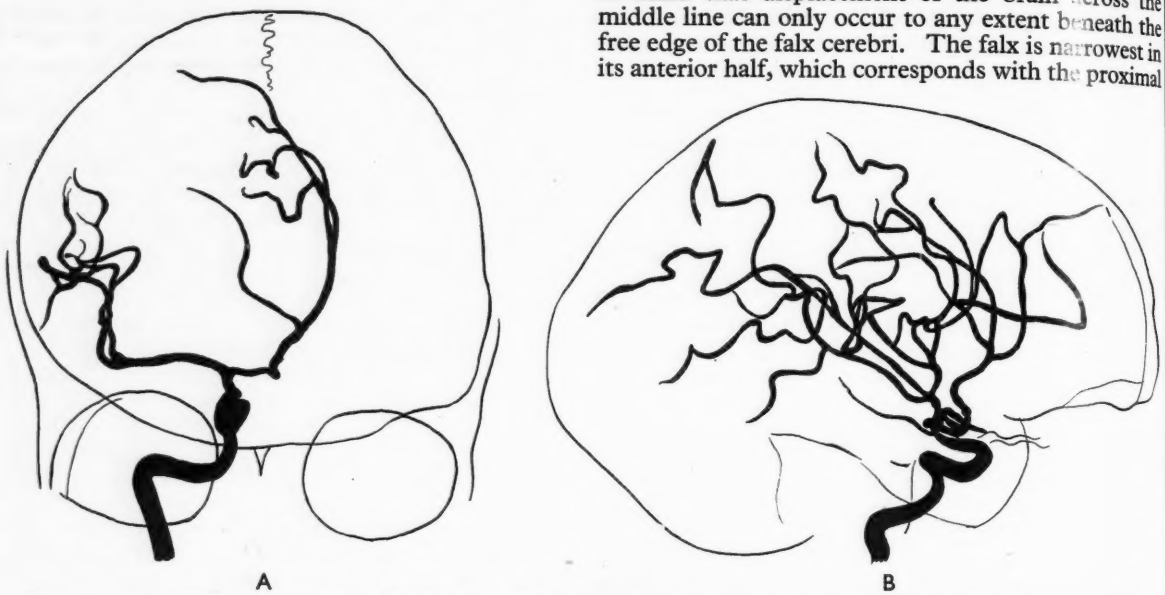


FIG. 474.—Astrocytoma of the right frontal lobe. A, A.P. arteriogram. The anterior cerebral is displaced to the opposite side in a wide arc which gradually returns to the middle line in its upper part. The middle cerebral shows no displacement. B, Lateral arteriogram. There is no specific displacement but the anterior cerebral group appears 'swept back'.

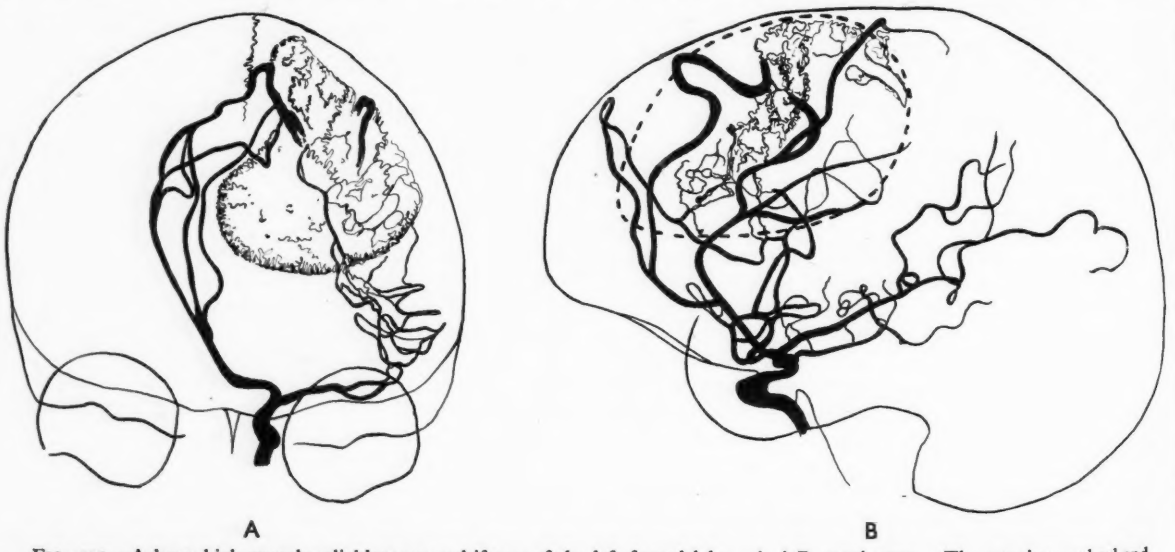


FIG. 475.—A large high vascular glioblastoma multiforme of the left frontal lobe. A, A.P. arteriogram. The anterior cerebral and its branches are displaced to the opposite side in a wide arc. The maximum displacement is high, corresponding to the site of the tumour. The area of pathological circulation is indicated. B, Lateral arteriogram. There is great enlargement of the branches of the anterior cerebral supplying the tumour. The whole of the area enclosed by the interrupted line had a pathological circulation part of which is indicated. The main anterior cerebral artery is not displaced. The middle cerebral group shows slight stretching.

tumours have been grouped in the following manner :—

A. Gliomas (108 cases) ;
B. Metastatic carcinomas (13 cases) ;
C. Meningiomas (42 cases) ;
D. Cerebral abscess (13 cases) ;
E. Pituitary and suprasellar tumours (7 cases).

GROUP A. GLIOMAS

It will be convenient first to consider the vascular displacements in relation to the site of tumour, and then to describe the pathological circulation of the different types of glioma. Owing to their extensive growth and infiltration gliomas are unsuitable for the elaborate subdivisions of site adopted by some authors (Fischer, 1939 ; Wickbom, 1948). The following subdivisions will therefore be used :—

Above the Sylvian fissure
1. Frontal ;
2. Frontoparietal or Rolandic ;
3. Parietal and Parieto-occipital ;
4. Sylvian, Anterior and Posterior.

Below the Sylvian fissure
5. Temporal and Temporo-occipital ;
6. Central or Deep.

Vascular Displacements with Gliomas

Frontal.—There were 27 cases, of which 13 were mainly in the centre of the frontal lobe and 5 of these were bilateral, 8 were mainly high, and 6 mainly posterior (*Figs.* 474–477).

The Anteroposterior Projection.—

1. Frontal tumours displace the medial surface of the frontal lobe, and consequently the anterior

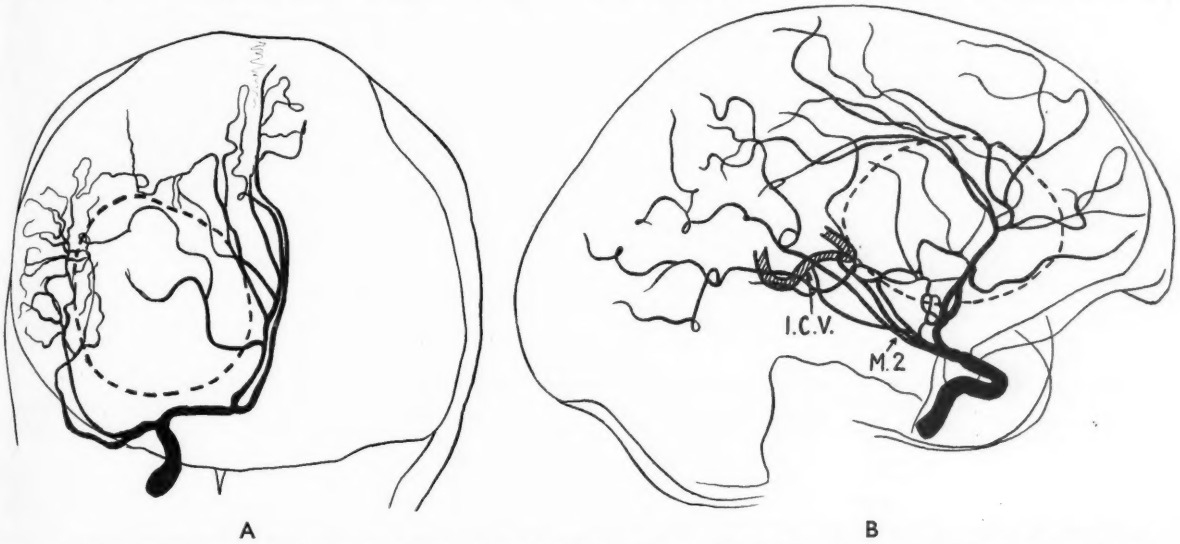


Fig. 476.—Frontal glioblastoma multiforme involving the pre-Rolandic area. A, A.P. arteriogram with the area of pathological circulation outlined. The anterior cerebral shows a slightly curved displacement but it is straighter than with tumours placed more anteriorly. The carotid bifurcation is flattened and M1 is depressed. The middle cerebral branches appear normal. B, Lateral arteriogram. The anterior cerebral group looks 'swept back', and the genu is opened out. The middle cerebral group at M2 is stretched and displaced downwards. The internal cerebral vein (I.C.V.) is pushed backwards.

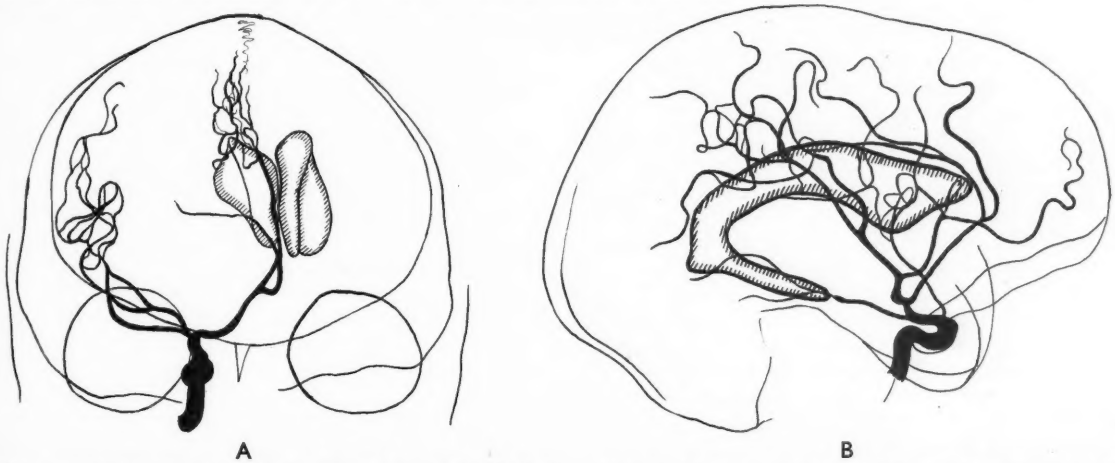


Fig. 477.—Astrocytoma deep in the posterior part of the right frontal lobe and in the anterior part of the basal ganglia. A, A.P. arteriogram. The displacement of the anterior cerebral is partially curved and is maximal low down. The ventricular outline shows the absence of filling of the lower part of the right anterior horn and the correlation of the shifts of the ventricular system and anterior cerebral artery. B, Lateral arteriogram. The anterior cerebral shows no deformity. The middle cerebral group is not depressed at M2 as it is too far lateral to be affected by the tumour. The right ventricular outline shows partial obliteration of the anterior horn from below.

cerebral artery, beneath the falx. Other hemisphere tumours also generally do the same thing. However, the type of displacement in frontal tumours gives a characteristic appearance of the anterior cerebral artery in the A.P. projection. Firstly, the degree of displacement is greater in frontal tumours than in tumours of other parts of the cerebral hemisphere. Secondly, and most characteristic, the displacement of the anterior cerebral (A2, A3), described by Sanchez-Perez (1941) and Almeida Lima (1950), was not present in this group but only in the olfactory meningiomas. On the contrary, there was most frequently a depression of A2 and A3 downwards and forwards, and the curve of the genu was widened (14 cases). This appearance was greatest in all the bifrontal cases, but was not confined to them. In the unilateral tumours

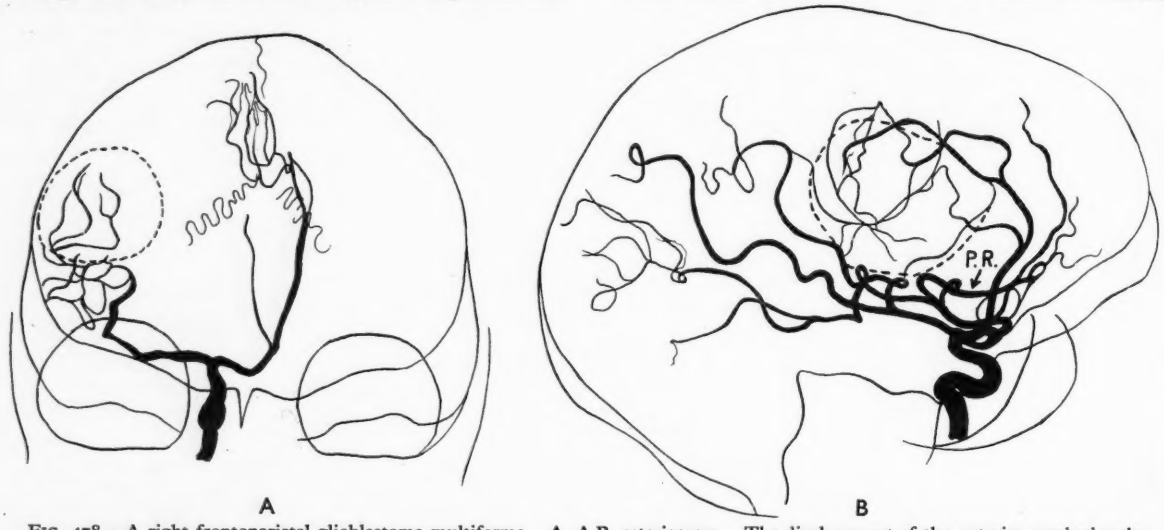


FIG. 478.—A right frontoparietal glioblastoma multiforme. A, A.P. arteriogram. The displacement of the anterior cerebral to the left is almost straight, but shows a slight curve. B, Lateral arteriogram. The middle cerebral group at M2 is stretched and slightly depressed. The pre-Rolandic artery (P.R.) is displaced forwards and downwards. The anterior cerebral artery shows no deformity. The area of pathological circulation is outlined.

is curved; this is an important point since, in the absence of a visible tumour circulation, precise localization of a frontal tumour by angiography may depend almost entirely on the interpretation of the curve of displacement of the anterior cerebral artery in the A.P. projection. The level of greatest displacement gives some indication of the level of the tumour (*Figs.* 475 A, 476 A, 477 A). In 2 cases of bifrontal tumours there was only slight displacement of the anterior cerebral artery and no curve.

2. The bifurcation of the internal carotid sometimes appeared flattened (Fischer, 1938). This flattening was present in 5 of 6 posterior tumours, 12 of 13 tumours of the centre, but only in 4 of the 8 situated high in the lobe. This flattened appearance of the bifurcation is difficult to reproduce photographically though it was obvious in the original films; *Fig.* 476 A gives some approximation.

3. Fischer described a " fronto-polar sign " which he considered to indicate a posterior frontal tumour. It consists of a kinking or indentation of the displaced anterior cerebral artery towards the side of the tumour, and this occurs at the origin of the fronto-polar artery, which, since it lies in front of the tumour, is not displaced to the same extent as the more distal portion of the anterior cerebral. In the present series this sign was only found in one-half of the posterior tumours, thus I do not consider it reliable.

4. There was no displacement of the middle cerebral artery, except slight depression of its first part (M1) in one low posterior tumour (*Fig.* 476 A).

The Lateral Projection.—

1. In the majority of frontal gliomas there was absence of specific deformity. Displacement backwards and upwards of the ascending portion of the it was probably due to stretching of the artery by its lateral displacement, or to the hydrocephalus which Lysholm, Ebenius, and Sahlstedt (1937) found in a third of their frontal tumours.

In 6 cases there was an appearance that the whole anterior cerebral system was swept backwards (*Fig.* 476 B), a feature also noted by Fischer (1938), List and Hodges (1946 a), and Wickbom (1948).

2. The pre-Rolandic artery was noticeably stretched backwards and downwards in 7 cases. In all these the tumour was laterally placed. This is an important sign when present and indicates that the tumour is superficial.

3. The Sylvian group of vessels showed stretching in the anterior lower part of the fissure, except in the high tumours. This was accompanied by a decrease in their ' parallel displacement '. (Contrast *Figs.* 475 B and 476 B).

4. The internal cerebral vein was identified in 14 phlebograms. In 9 of these it was distorted, and the anterior end, which indicates the site of the foramen of Monro, was displaced backwards (*Fig.* 476 B). In 2 high tumours it was depressed. Lysholm and others (1937) found the foramen of Monro displaced in about half of their ventriculographic series of frontal tumours.

Frontoparietal or Rolandic.—There were 14 cases, of which 2 were high and 5 low (*Figs.* 478–480).

The Anteroposterior Projection.—

1. In all but 1 case the anterior cerebra artery filled and was displaced to the opposite side. The pronounced curve of the frontal tumours, already described, was present in only 1 case. The displacement was mainly straight, but with a slight curve in 6

(*Fig.* 478 A), and without a curve in 6 (*Fig.* 479 A). In one of these the shift was very slight and corresponded to the minimal lateral shift of the anterior

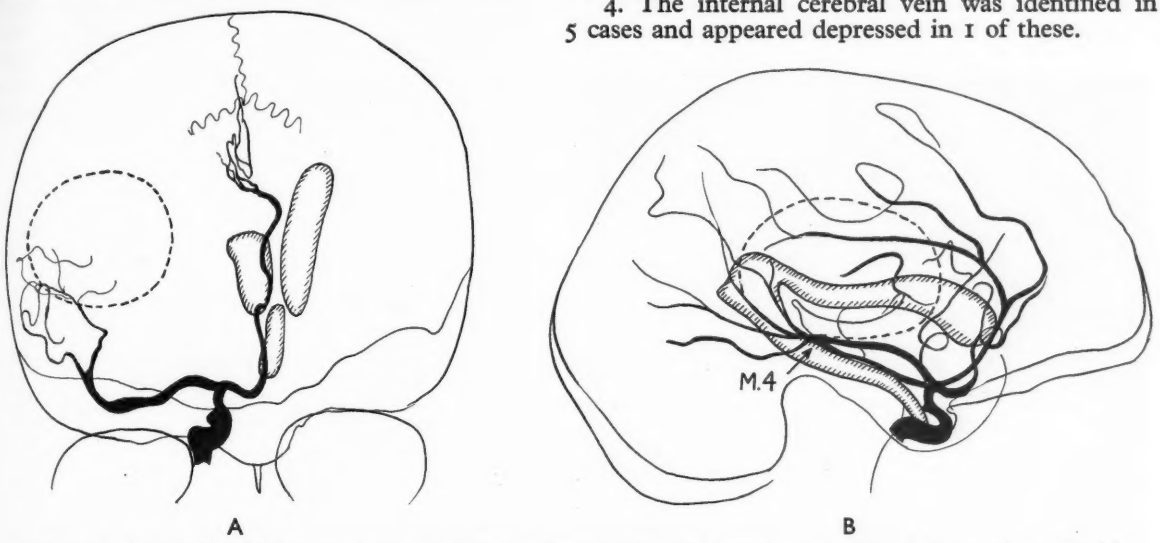


FIG. 479.—A right frontoparietal astrocytoma. A, A.P. arteriogram. The displacement to the left of the anterior cerebral is greatest in its upper part. The site of the tumour and the ventricles are outlined. B, Lateral arteriogram. The bulk of this tumour was posterior to the Rolandic fissure. The stretching of the middle cerebral and its depression are most marked at M4. The anterior cerebral shows no abnormality except slight stretching.

part of the ventricular bodies in the pneumoencephalogram (*Fig.* 479 A). In another the displacement was irregular, with a return to the middle line at a site which did not correspond to the origin of the frontopolar artery (*Fig.* 480 A).

2. The frontopolar sign was present in only 2 cases. The bifurcation of the internal carotid appeared flattened in 6 cases. The middle cerebral artery showed no deformity.

3. The anterior cerebral artery was not displaced, except in 3 cases which showed evidence of hydrocephalus.

4. The internal cerebral vein was identified in 5 cases and appeared depressed in 1 of these.

5. In 1 case there was obvious curved stretching of the posterior parietal arteries.

Parietal and Parieto-occipital.—There were 10 cases, of which 2 were parieto-occipital (*Figs.* 481–483).

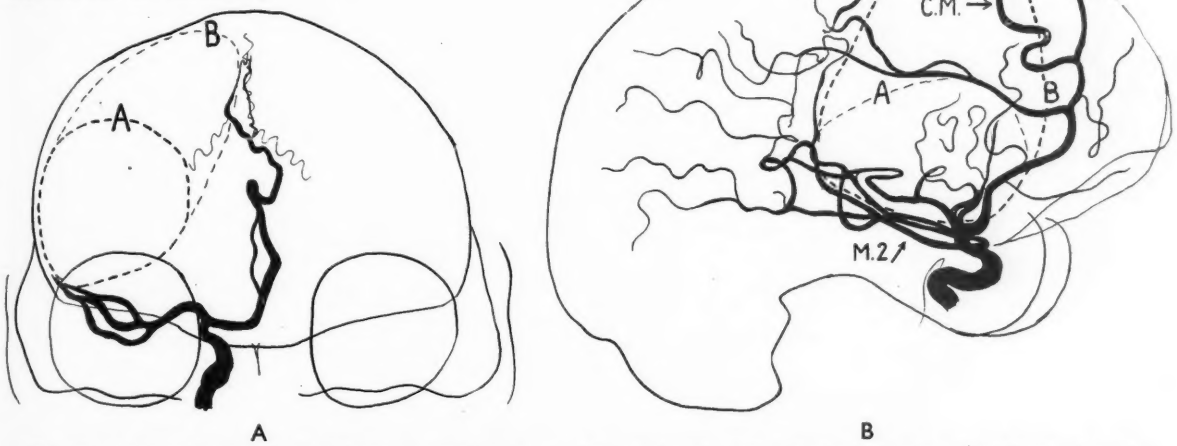


FIG. 480.—A large frontoparietal glioblastoma multiforme. A, A.P. arteriogram. The displaced anterior cerebral has an irregular shape. The pathological circulation (A) and total extent of the tumour (B) are outlined. B, Lateral arteriogram. The middle cerebral group at M2 is stretched and depressed. The area of pathological circulation is much smaller than the total size of the tumour found at autopsy. Interpretation of the film at the time overlooked the evident enlargement of the marginal callosal artery (C.M.) which was feeding the tumour.

The Lateral Projection.—

1. The most constant features were a decrease in parallel displacement of the Sylvian group (12 cases), and obvious stretching of the Sylvian group of vessels (13 cases); the vessels were also obviously depressed in 9 of these (*Figs.* 478 B, 479 B, 480 B).

2. The pre-Rolandic artery was displaced forwards in 6 cases (*Fig.* 478 B).

The Anteroposterior Projection.—

1. As might be expected, the more posterior the situation of the tumour the less the lateral displacement of the anterior cerebral artery. Thus, the two parieto-occipital tumours showed no displacement, but the internal cerebral vein was displaced in the phlebograms. The others showed a shift without a curve, due not to the direct effect of the tumour on

the artery, but to displacement of the medial surface of the affected hemisphere beneath the free edge of the falx (*Figs.* 481 A, 482 A, 483 A). It was the proximal part of the anterior cerebral which was displaced (A2 and A3 and at times the proximal part of A4). At its distal end the displacement frequently showed a fairly abrupt return to the middle line (*Fig.* 481 A).

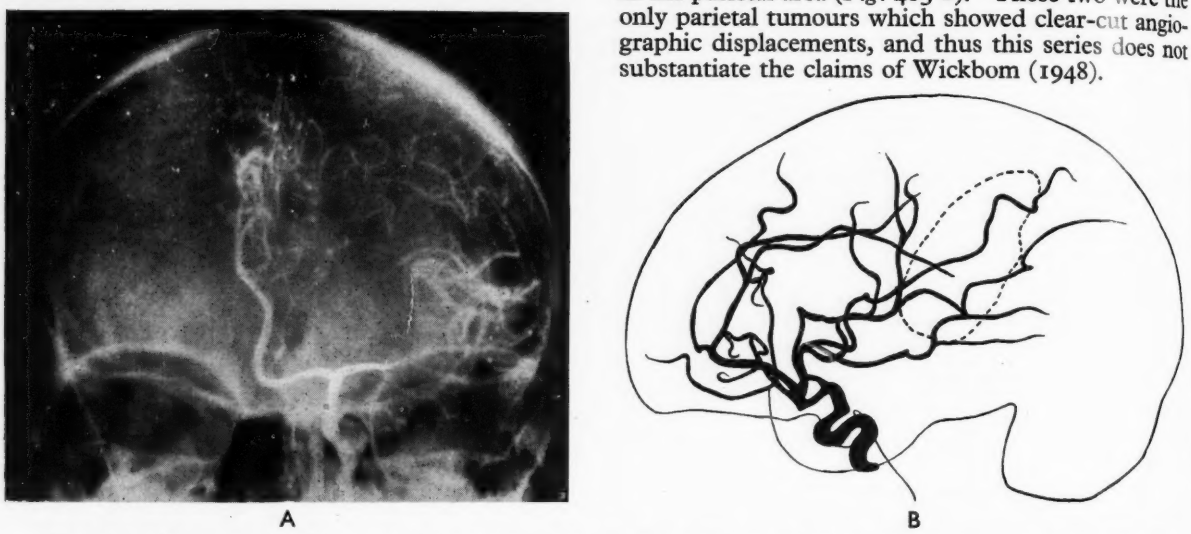


FIG. 481.—A deep cystic astrocytoma of the parietal lobe. A, A.P. arteriogram showing lateral displacement of the anterior cerebral with absence of displacement of the middle cerebral group. B, The lateral arteriogram is normal. The extent of the cyst following aspiration of its contents and replacement by air is outlined.

2. There was no deformity of the middle cerebral artery, except in one case in which its branches were distorted (*Fig.* 483 A).

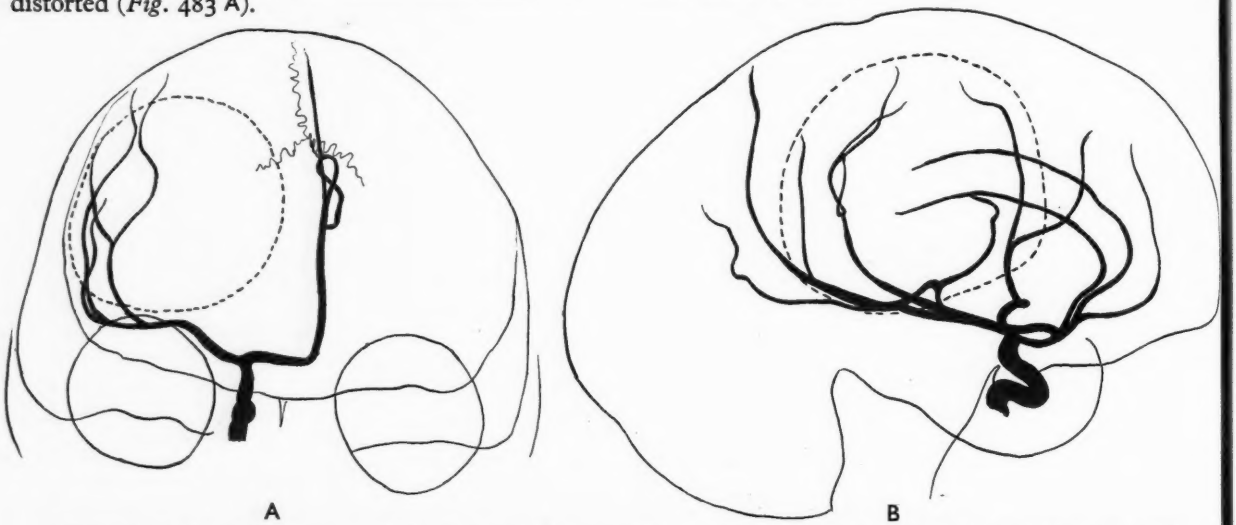


FIG. 482.—A large glioblastoma multiforme of the right parietal lobe. A, A.P. arteriogram. There is a straight linear lateral displacement of the anterior cerebral to the left, a little accentuated by slight rotation of the face to the left. The Sylvian vessels are stretched. The tumour circulation is outlined. B, Lateral arteriogram to show the vascular displacement when the tumour is superficial or large. The Sylvian group at the posterior end of the fissure and its parietal branches are grossly stretched and depressed.

The Lateral Projection.—

1. In all cases the anterior cerebral artery appeared normal.

2. With most parietal tumours, and especially the deep ones, there was remarkably little abnormality of the middle cerebral and its distal branches (*Fig.* 481 B); in the absence of a pathological circulation the lateral picture showed little which was diagnostic. In one large tumour the middle cerebral branches were displaced down at the posterior end of the Sylvian fissure (*Fig.* 482 B); and with one superficial tumour there was obvious stretching of the vessels in the parietal area (*Fig.* 483 B). These two were the only parietal tumours which showed clear-cut angiographic displacements, and thus this series does not substantiate the claims of Wickbom (1948).

3. The internal cerebral vein was depressed in 3 cases.

Sylvian.—There were 10 cases, of which 6 were anterior or frontotemporal and 4 posterior or parietotemporal (*Fig.* 484).

As might be expected, these tumours in close relation to the Sylvian fissure showed a mixture of characteristics depending on the lobes they involved.

The Anteroposterior Projection.—

1. Of the 4 frontotemporal tumours in which this view was taken 1 showed no filling of the anterior cerebral, 2 showed a straight displacement with an

abrupt return to the middle line, and 1, mainly frontal, showed a slightly curved displacement (*Fig.* 484 A). The four cases showed slight, definite, but not gross, upward displacement of M1 (*Fig.* 484 A).

3. In the parietotemporal tumours there was no deformity of the pre-Rolandic artery. The Sylvian group usually appeared bunched and pushed forwards, or elevated. Two showed some hydrocephalic

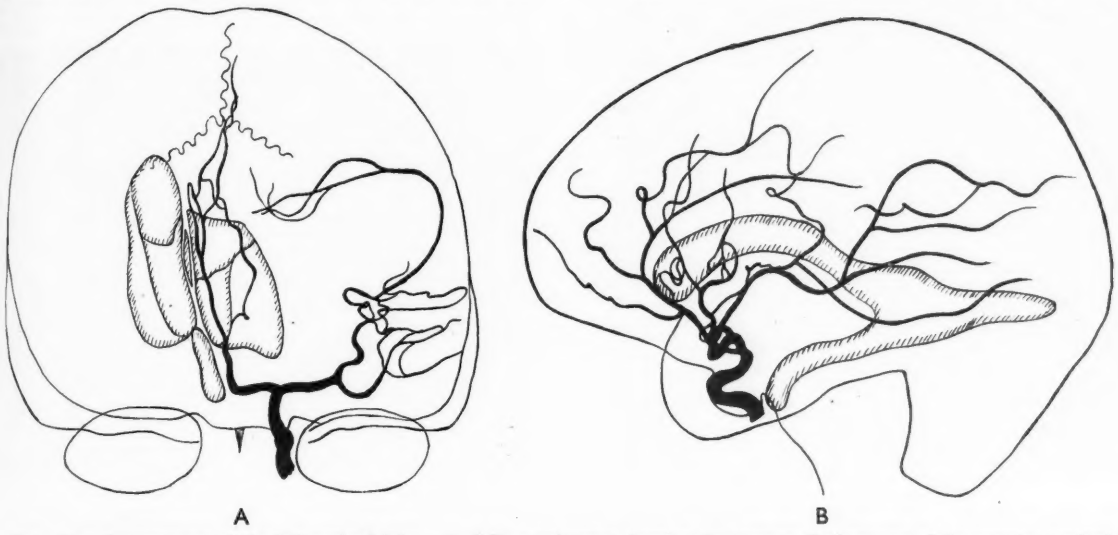


FIG. 483.—Astrocytoma of the left parietal lobe. A, A.P. arteriogram showing the greatest displacement of the anterior cerebral in its upper part. The shift of the anterior cerebral is seen to correspond with the shift of the lateral ventricles. The middle cerebral arteries in the Sylvian fissure are slightly distorted and one of the posterior branches is obviously stretched. B, Lateral arteriogram. The anterior cerebral group appears normal. The branches of the middle cerebral group at the posterior end of the Sylvian fissure are curved and stretched in contrast to their normal wavy appearance. The left ventricle shows the deformity produced by the tumour which lay above and lateral to it.

2. Both parietotemporal tumours with A.P. views showed a straight displacement of the anterior cerebral. They showed no displacement of M1.

The Lateral Projection.—

1. Of the 6 frontotemporal tumours, 4 showed changes in the anterior cerebral similar to those with frontal tumours.

stretching of the arteries. No deformity of the internal cerebral vein was noted.

In spite of the great variations in this group, their situation could be diagnosed by angiography with considerable precision. Tumours spreading across the Sylvian fissure inevitably produce some displacement of the adjacent vessels.

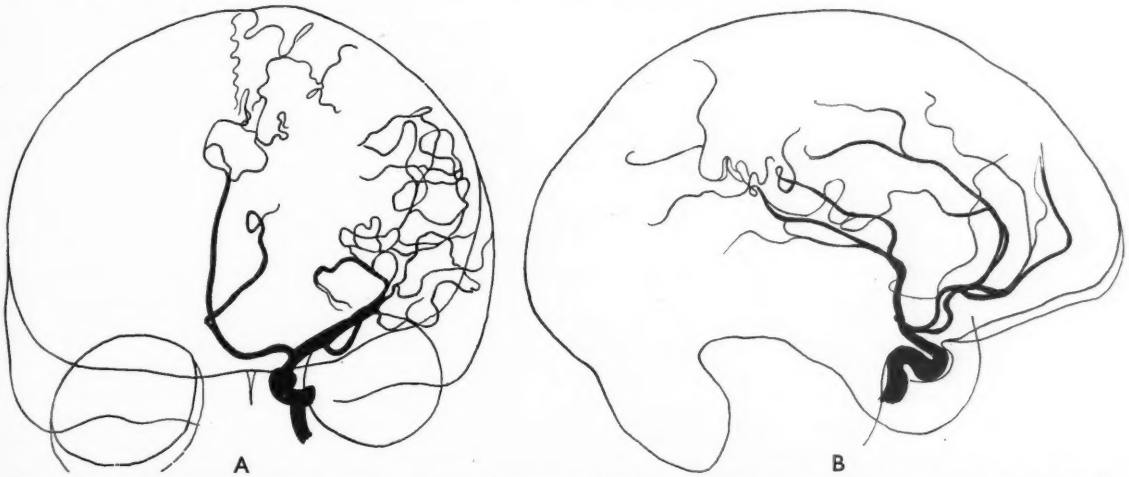


FIG. 484.—A frontotemporal astrocytoma. A, A.P. arteriogram. The lateral displacement of the anterior cerebral is mainly straight but is slightly curved in its lower part. The middle cerebral at M1 is slightly elevated and stretched. B, Lateral arteriogram. The upper limb (C2) of the siphon, C1 and M1 appear pushed down and back. More posteriorly the middle cerebral vessels at M1 and M2 are elevated as in a temporal tumour. The anterior cerebral shows no displacement.

2. They all showed deformities in the region of the Sylvian fissure (*Fig.* 484 B). The early part of the middle cerebral (M1) was elevated to some extent. In 5 cases the pre-Rolandic artery was either enlarged and feeding a tumour circulation, or markedly stretched and deformed. In 3 cases the internal cerebral vein was depressed and displaced backwards.

Temporal and Temporo-occipital.—There were 39 cases, of which 8 were temporo-occipital (*Figs.* 485–487).

The Anteroposterior Projection.—

1. With few exceptions the anterior cerebral was displaced to the opposite side, with an abrupt return to the middle line at the upper surface of the corpus

callosum (*Fig.* 485 A), as in the parietal tumours. In one case only the lower part of the artery was displaced, and this displacement was curved. In one no abnormalities of the middle cerebral, but a half-axial view clearly revealed distortion of the posterior part of the Sylvian group (*Fig.* 487 A, B). In some cases where the tumour was anterior the posterior

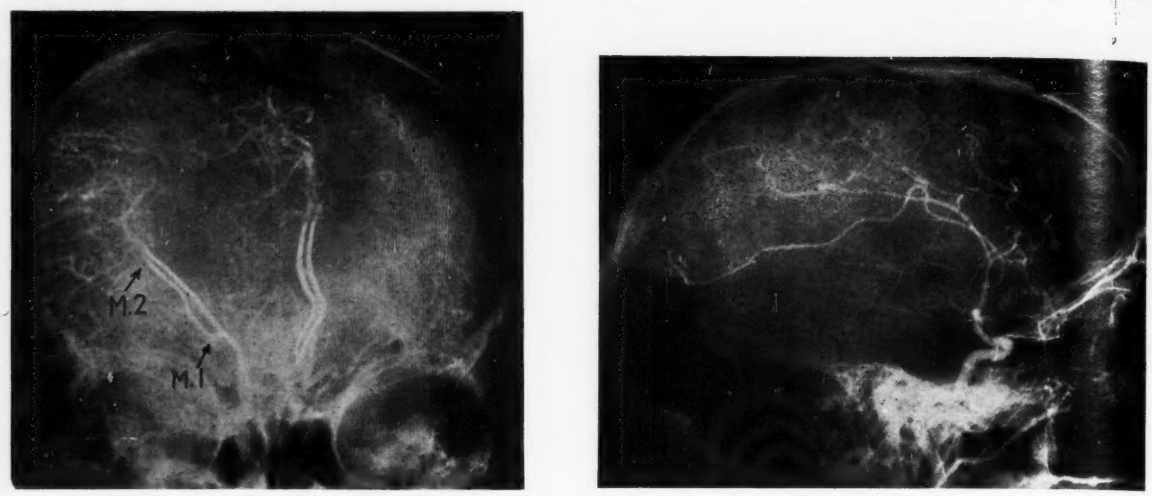


FIG. 485.—A, A.P. arteriogram of a large temporal glioblastoma multiforme. The anterior cerebrals which are both shown are displaced without being bowed. The early part of the middle cerebral (M1) is displaced upwards and inwards and M2 is also elevated. B, Lateral arteriogram of a similar case showing the extreme arched upward displacement of the whole of the middle cerebral group.

there was no appreciable shift, a finding confirmed by subsequent air studies.

2. There were two types of displacement of the middle cerebral artery. In large tumours, and in small tumours situated anteriorly, M1 was elevated upwards and inwards and tended to continue in a straight line with M2 (*Fig.* 485 A). If the tumour was more posterior M1 was only slightly, or not at all, elevated, but M2 was always displaced upwards and inwards and appeared less foreshortened as a result (*Fig.* 486 A). In the temporo-occipital tumours the ordinary anteroposterior projection might show cerebral, when it filled from the internal carotid, was shifted towards the opposite side.

The Lateral Projection.—

1. The characteristic sign was elevation of the branches of the middle cerebral artery in the Sylvian fissure. Generally this was in a wide arc and might be so gross as to superimpose these vessels on the pericallosal artery (*Fig.* 485 B). With temporo-occipital tumours and abscesses the displacement was most marked posteriorly (*Figs.* 486 B, 488 A). With some anteriorly placed tumours the upper limb of the siphon was also slightly elevated.

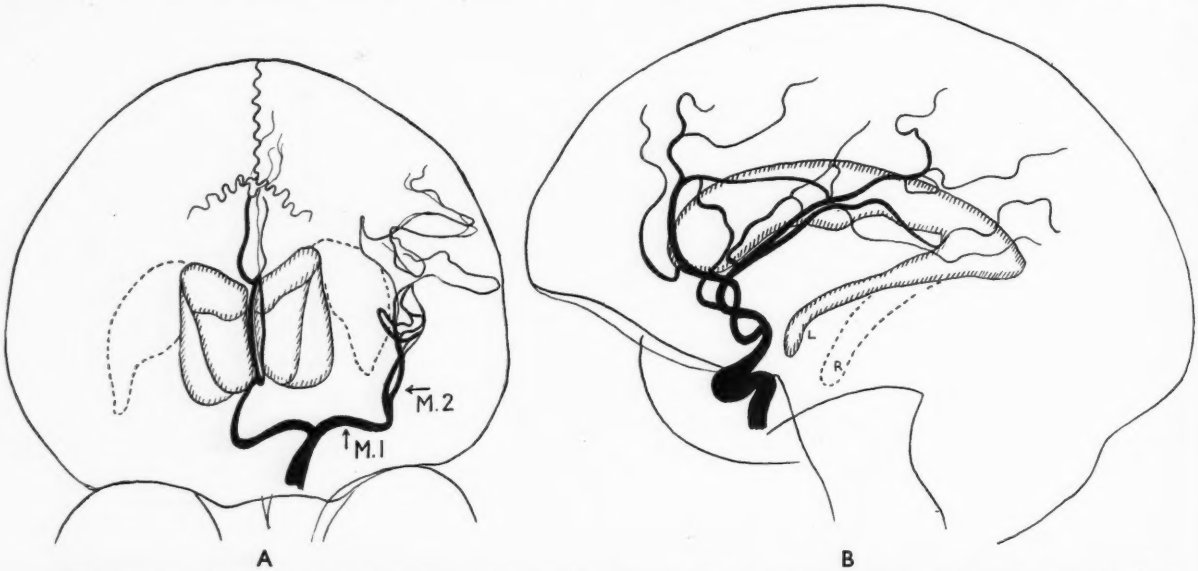


FIG. 486.—A cerebral abscess in the posterior part of the left temporal lobe. A, A.P. arteriogram. The anterior cerebral shows slight lateral displacement. M1 of the middle cerebral is not elevated but M2 is less foreshortened than normal, indicating that it has been pushed up. B, Lateral arteriogram. The upward displacement of M1 and M2 is not so marked as in *Fig.* 485 B. The ventricular tracing shows the elevation of the left inferior horn (L) as compared with the right (R).

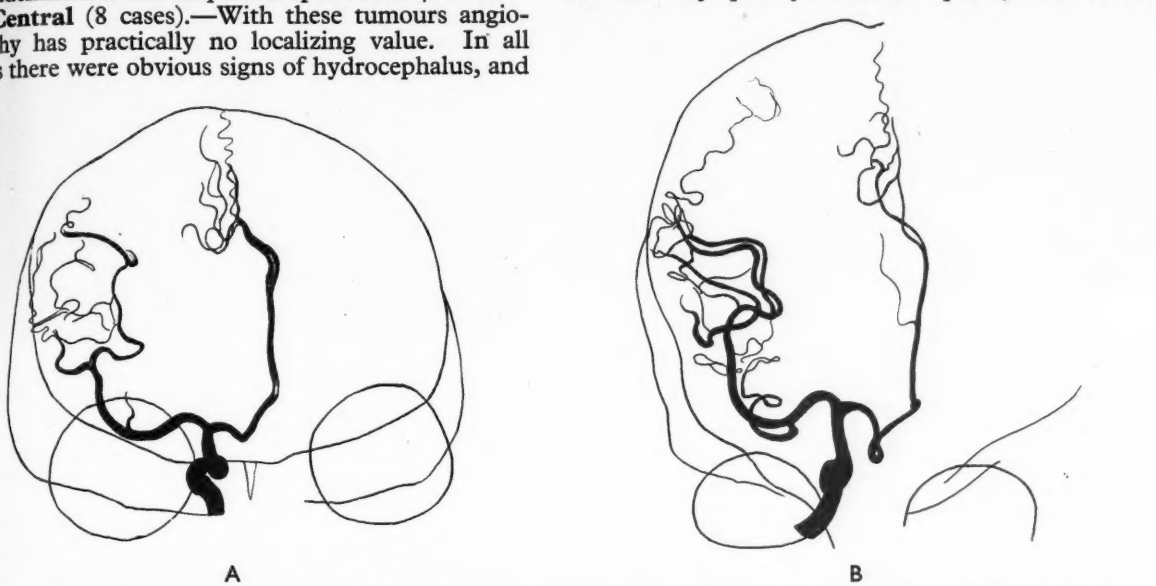
2. The observation of Almeida Lima (1950) that the posterior temporal artery is elevated in the superficial tumours and normal in its course in the deep has not been constant in this series.

3. In 9 cases there was hydrocephalic stretching of the anterior cerebral, but otherwise this vessel showed no deformity.

4. In those cases where the posterior cerebral artery filled (10 of the 39 cases) it was stretched and depressed in 6 cases.

5. In 23 cases where the internal cerebral vein was identified it was displaced upwards in 7 cases.

Central (8 cases).—With these tumours angiography has practically no localizing value. In all cases there were obvious signs of hydrocephalus, and the localization of the lesion to the region of the third ventricle was made by ventriculography. In one case the arteriographic signs of hydrocephalus were accompanied by a slight lateral shift of the anterior cerebral in its lower part. These signs might be interpreted as caused by a deep unilateral tumour, but could equally well be produced by a more superficial frontal tumour. The distortion of the anterior choroidal artery and internal cerebral vein, which was sometimes present, could not be distinguished from the appearance produced by hydrocephalus.



A B

FIG. 487.—A large temporo-occipital glioblastoma multiforme. A, Routine A.P. projection. There is no displacement of the middle cerebral group apart from slight elongation (less foreshortening) of M2 owing to its upward displacement (cf. *Fig.* 468 A). The anterior cerebral shows a straight lateral displacement. B, Half axial projection (35° tilt). The distortion of the middle cerebral vessels posteriorly is now apparent.

PATHOLOGICAL CIRCULATION OF GLIOMAS

1. Glioblastoma Multiforme (58 cases).—Pathological circulation present in 44 (75 per cent).

These figures may be compared with those obtained by Hemmingson (1939), 86 per cent, Lorenz (1940), 53 per cent, List and Hodges (1947), 40 per cent, and Wickbom (1948), 70 per cent. Of the 14 cases in which no pathological circulation could be detected, biopsy or autopsy revealed that 8 consisted mainly of necrotic or cystic material, corresponding to the avascular zone of Hardman's (1940) classification.

Since the introduction of rapid serial angiography it has been possible to study 8 cases with this method, and 7 of these showed evidence of a pathological circulation at some stage of the circulation of contrast. Two of these seven showed pathological vessels at periods which would have been missed by the routine method of two or three exposures.

The circulation of a glioblastoma multiforme is usually rapid. There may be obvious arteriovenous connexions, the veins filling with contrast during the arterial phase. In such cases the tumour area showed irregular collections of contrast with a diameter up to 3–4 mm. These probably correspond to the sinusoidal spaces demonstrated by Hardman (1940). With rapid serial films it is seen that the contrast very quickly fills these spaces, even before there is good filling of the smaller arteries elsewhere (*Fig.* 488 A at 2·0 sec.*). And the veins which drain the sinusoidal spaces appear well filled at 2·5–3·0 sec., before the normal veins have received any contrast (*Figs.* 488 B, C, 490). Despite this early filling of veins, however, the emptying of the sinusoidal spaces is a slower process than their filling, and traces of contrast may still be seen in them at 4·5–5·0 seconds. However, their circulation is much more rapid than the circulation of the rest of the brain.

There may be no gross arteriovenous fistulæ, so that the irregular collections of contrast fill more slowly and appear clearly at 3 to 4 seconds. It is in the diagnosis of this type of case that rapid serial angiography has proved of surgical value, and one may presume that by this method some area of pathological circulation will be found in a greater proportion of malignant tumours.

Where there is a gross tumour circulation, with arteriovenous fistulæ, the contrast quickly collects in the tumour, and the circulation of the rest of the brain often appears to be meagre. Such a deficiency of circulation in the cerebral hemisphere containing a malignant glioma might be a factor in producing symptoms.

* All timing mentioned in this section refers to the time elapsed from the beginning of the injection.

Other types of abnormal vessels have also been seen :—

a. Fine slightly wavy vessels of irregular diameter and pattern which may show filling in the arterial phase (*Fig.* 489). These vessels may be present in a part of the glioma which shows no sinusoids, and their angiographic demonstration may thus be important in indicating the full extent of the tumour.

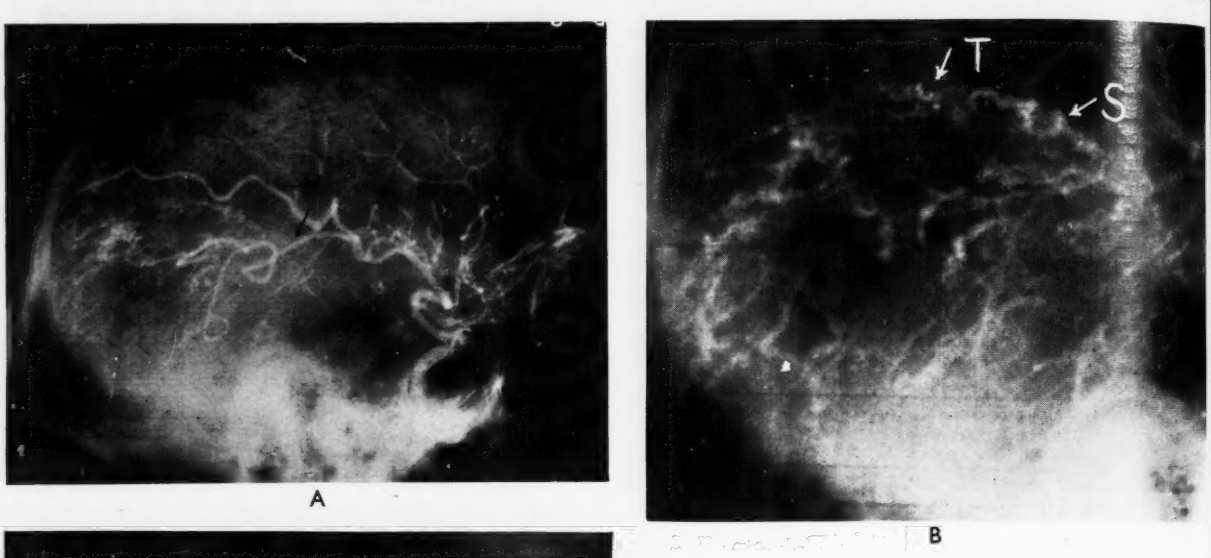


FIG. 488.—The pathological circulation of a temporo-occipital glioblastoma multiforme shown by rapid serial angiography. A, At 2·0 sec. from the start of the injection. Enlarged branches (H) of the middle cerebral artery are supplying the tumour. There is early filling of the tumour vessels. B, At 2·5 sec. The tumour circulation is well shown. There are irregular spaces (S) and smaller finely-coiled short vessels (T) about 1 to 2 mm. in diameter. The diodone has almost faded from the arteries. C, At 3·0 sec. There is no diodone in the arteries and it has not yet appeared in the veins of the rest of the brain. The tumour circulation stands out. Veins (V) are draining the tumour. At 5·0 sec. the diodone had faded considerably from the tumour, and at this time the veins elsewhere were commencing to fill.

They are more easily demonstrated by serial angiography, than by the routine 2- or 3-film method.

b. The vessels supplying the tumour are frequently dilated (*Fig.* 488 A). Their identification is

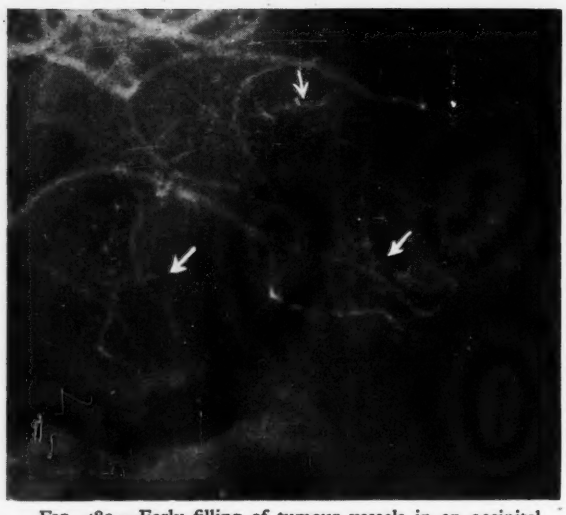


FIG. 489.—Early filling of tumour vessels in an occipital glioblastoma multiforme. Thin spidery vessels and those of larger diameter are indicated by arrows.

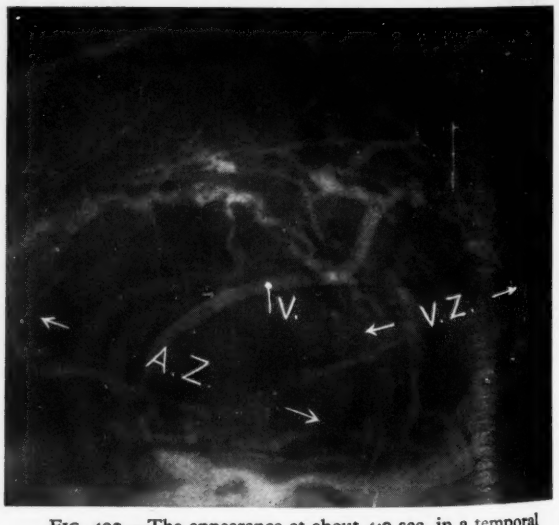


FIG. 490.—The appearance at about 4·0 sec. in a temporal glioblastoma multiforme. A vascular zone (V.Z.) surrounds a central avascular zone (A.Z.). These zones correspond to those described by Hardman. In the vascular zone there are thin vessels lying closely packed parallel to each other, and some larger sinusoidal spaces. Large veins (V) are draining the area.

of help in localization but this finding is not confined to glioblastoma multiforme.

c. There may be fine irregular dots of contrast, with a diameter of about 1 mm., with short, curly, irregular vessels lying scattered between them. Lorenz (1940) has noted that these vessels appear

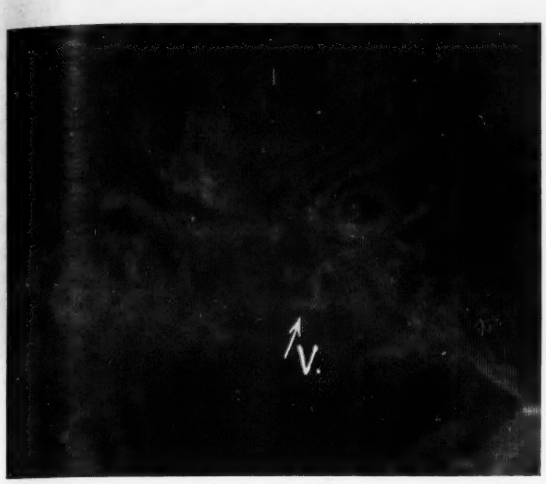


FIG. 491.—Lateral view at about 8 sec. in a frontal glioblastoma multiforme. A collection of irregular venous spaces is seen in the centre of the tumour area. The smaller veins (V) coil and are of fairly short length.

to have no beginning or end. Sometimes these vessels may be faint and they have a spidery appearance. They appear later than the arterial phase, usually at 3 to 4 seconds and before the venous drainage elsewhere is fully developed (*Figs.* 488 B, 490).

phase. The channels are irregular and of wide calibre compared with their short course (*Fig.* 491). In the second type there are short dilated veins running in a circular fashion around the tumour area. This

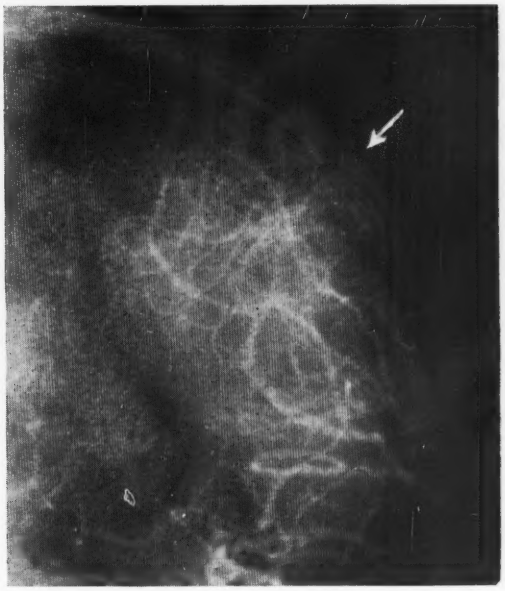
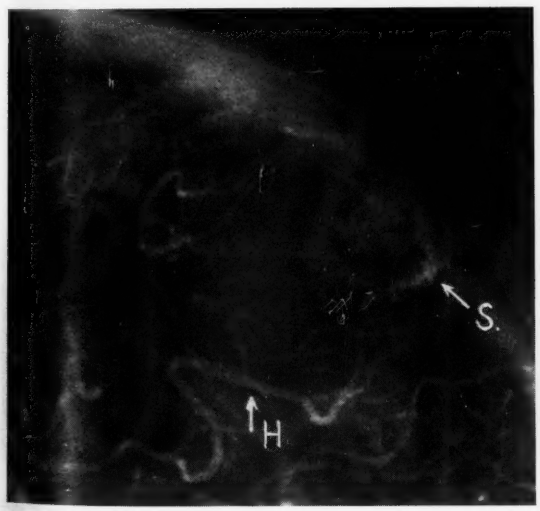


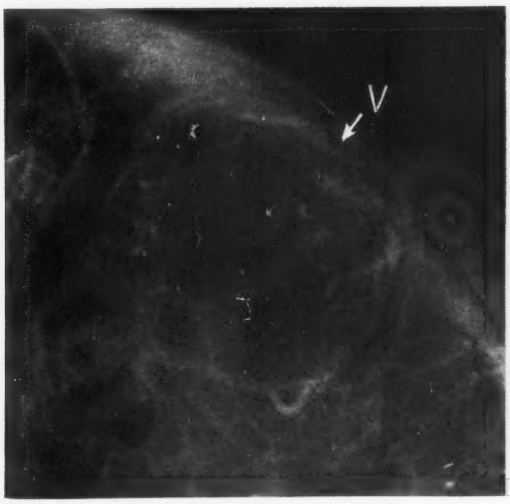
FIG. 492.—A.P. arteriogram of an astrocytoma similar to the one described in the text. The roughly star-shaped collection of vessels is indicated by the arrow.

type is liable to be confused with the venous drainage of a meningioma.

2. Astrocytoma (48 cases).—Pathological circulation present in 4 cases.



A



B

FIG. 493.—A high Rolandic astrocytoma (*Case* 3). A, Lateral arteriogram. An enlarged vessel (H) is passing up to the right, to the posterior part of the tumour area, which contains an irregular sinusoidal space (S). B, Film taken 2 sec. later, showing the venous drainage (V) outlining the tumour. The centre is fairly avascular.

d. Apart from the arteriovenous fistulæ mentioned above, two types of venous drainage have been observed. Both are important, as they may be the only evidence of a pathological circulation. In the first there may be a roughly star-shaped arrangement of venous channels radiating out from the centre of the tumour circulation in the later venous

Case 1.—*Posterior Sylvian Astrocytoma.* There was a star-shaped collection of vessels in the tumour region. These were about 1–2 mm. in diameter and did not show irregularity of lumen, but were unlike vessels seen normally (*Fig.* 492).

Case 2.—*Parietal Astrocytoma.* The film taken at about 3½ sec. showed a collection of regular vessels

similar to those seen in *Case* 1, but lying parallel with each other. They appeared to be draining into normal veins.

Case 3.—*High Rolandic Astrocytoma.* The arteriogram showed hypertrophied vessels feeding the tumour.

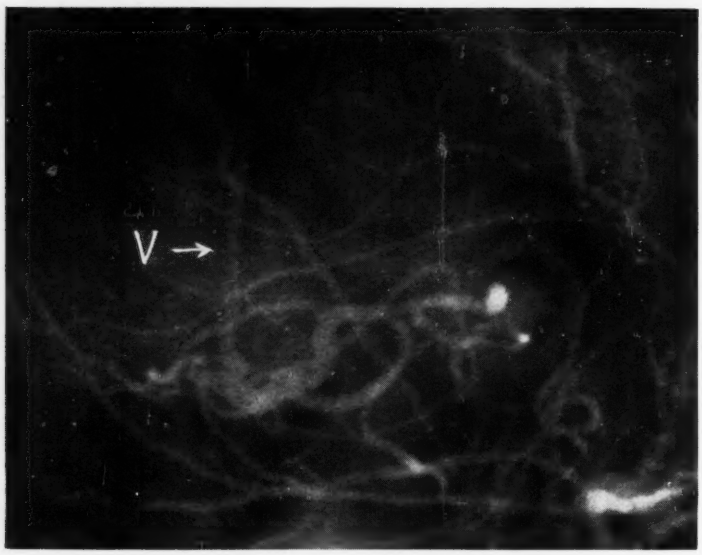


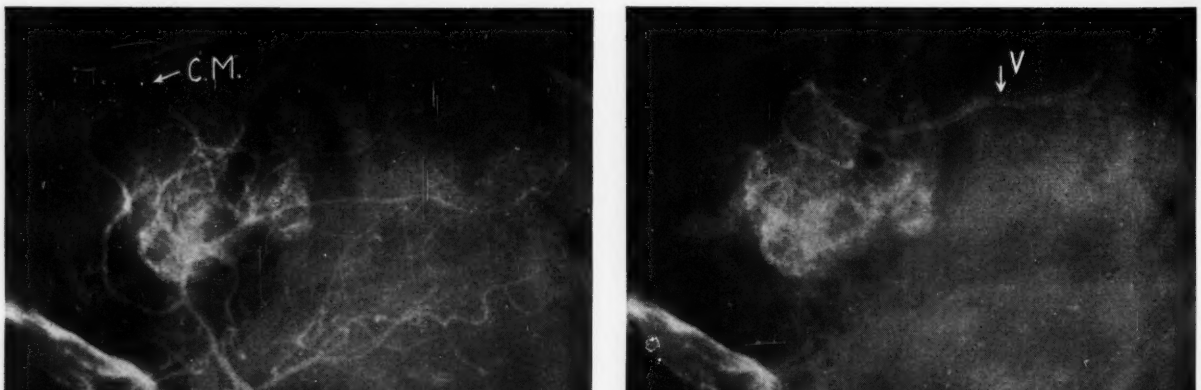
FIG. 494.—Lateral arteriogram of a low frontoparietal astrocytoma with an arteriovenous fistula (*Case* 4). The vein draining the area is indicated (V).

Smaller branches were running in a circular fashion around the tumour area. There was an irregular collection of contrast at the posterior part of the tumour which resembled a sinusoidal space (*Fig.* 493 A). In the film taken 2 sec. later there was drainage of the tumour area by veins surrounding it in a circular fashion (*Fig.* 493 B). These features of a fast pathological circulation with this type of venous drainage suggested a malignant tumour, and it is of interest that histological sections of the tumour showed that although it was predominantly astrocytomatous there was evidence of de-differentiation to a more primitive cell type. The patient died of recurrence one year after removal of the tumour.

Case 4.—*Frontoparietal Astrocytoma.* The appearance in this case was curious. The tumour was a large one. There was a gross arteriovenous fistula without irregular sinusoids and with a large vein already filled with contrast in the arteriogram (*Fig.* 494). So striking was the appearance that either an angiomatous malformation or a glioblastoma was suspected. At operation a large tumour was removed which histologically was an astrocytoma. When last heard from 2½ years later the patient was well.

Summarizing, it may be said that a pathological circulation is rare in astrocytomas and that we have insufficient examples in our series to draw definite conclusions. It would appear that an astrocytoma should be suspected if there is a collection of unusual fine vessels without gross irregularity of lumen or course, and with a circulation not noticeably faster than that of the rest of the brain. More frequently the tentative diagnosis of astrocytoma is made on the negative finding of avascularity. In addition, further experience may show that malignancy in astrocytomas may be indicated by angiographic appearances of the type seen in *Case* 3.

3. *Oligodendroglioma* (2 cases).—In one of these the rapid serial method showed hypertrophied arteries supplying the tumour (*Fig.* 495 A), and drainage by an enlarged vein which was well filled with diodone before the venous drainage of the rest of the brain showed (*Fig.* 495 B). Venous drainage of the tumour was complete by 6 sec., whereas elsewhere venous drainage continued until 10 sec. and was not so well marked. In this one example there were evidently tumour vessels in the capillary part of the tumour circulation which enabled the contrast to pass through more quickly and in greater quantity than in the normal brain tissue; but any details which may have been present were obscured by the calcification.



A B

FIG. 495.—Calcified frontal oligodendroglioma. A, Rapid serial film taken at 1½ sec. It shows the arterial phase and there is an enlarged marginal callosal artery (C.M.) passing to the tumour area. B, Film taken at 3½ sec. The vein (V) draining the tumour is well filled with contrast and no veins are filled elsewhere. The calcification obscures any details there may be of a tumour circulation.

GROUP B. METASTATIC CARCINOMAS

There were 13 cases, of which 5 had multiple tumours. These cases showed no features of vascular displacement different from those in the glioma group unless there were multiple tumours. The pathological diagnosis was often difficult. Eight showed no recognizable pathological circulation. Four of the other 5 cases resembled a glioblastoma multiforme angiographically. In one of these (*Fig.* 496) there appeared to be two obvious tumours, one of which was vascular and one avascular, and the correct diagnosis was made on this multiplicity. In the remaining case the appearance suggested a meningioma with a pathological circulation of fine vessels which was fed by an enlarged middle meningeal artery; at operation the metastatic tumour was found attached to the dura. We have not observed any cases which showed a capillary blush similar to a meningioma, as described by Wickbom (1948).

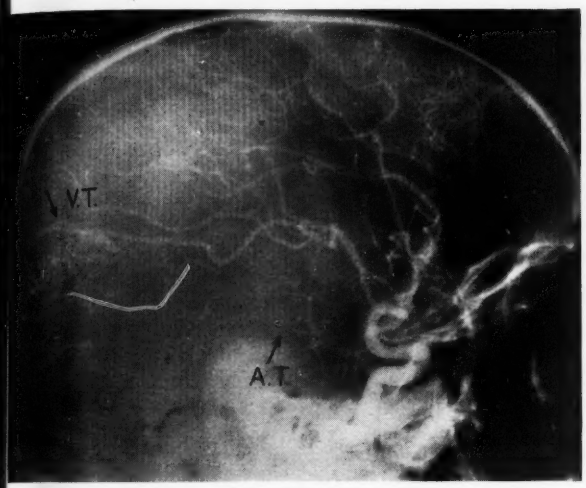


FIG. 496.—Lateral arteriogram of a case with multiple metastatic carcinomas. In the occipital lobe there is one vascular tumour (V.T.) with a pathological circulation resembling that of a glioblastoma multiforme. The upward displacement of the anterior part of the Sylvian group indicates a second avascular tumour (A.T.) in the anterior part of the temporal lobe.

GROUP C. MENINGIOMAS

There were 42 cases, which were situated as follows: Frontal 3; Frontal parasagittal 8; Frontoparietal (Rolandic) 5; Frontoparietal parasagittal 3; Parietal 2; Parietal parasagittal 6; Temporal 4; Sphenoidal-ridge (including cavernous sinus and basal middle fossa) 5; Olfactory-groove 2; Suprasellar 4.

Localization. — In general, meningiomas in similar sites produced the same type of vascular displacement as gliomas of the cerebral hemispheres. But, because of their non-infiltrating nature, their dural attachments, and their occurrence in certain characteristic sites, there were some features of vascular displacement which appeared to be peculiar to meningiomas.

1. Sometimes the smaller cortical vessels appeared to be stretched in a curved fashion around the site of the tumour (*Fig.* 497 A, B). This was seen best with falx or parasagittal tumours in the anteroposterior projection.

2. Parasagittal or falx tumours (frontal, frontoparietal, or parietal) all tended to displace the anterior cerebral artery more at its upper than its lower part, as seen in the anteroposterior projection (*Fig.* 497 A).

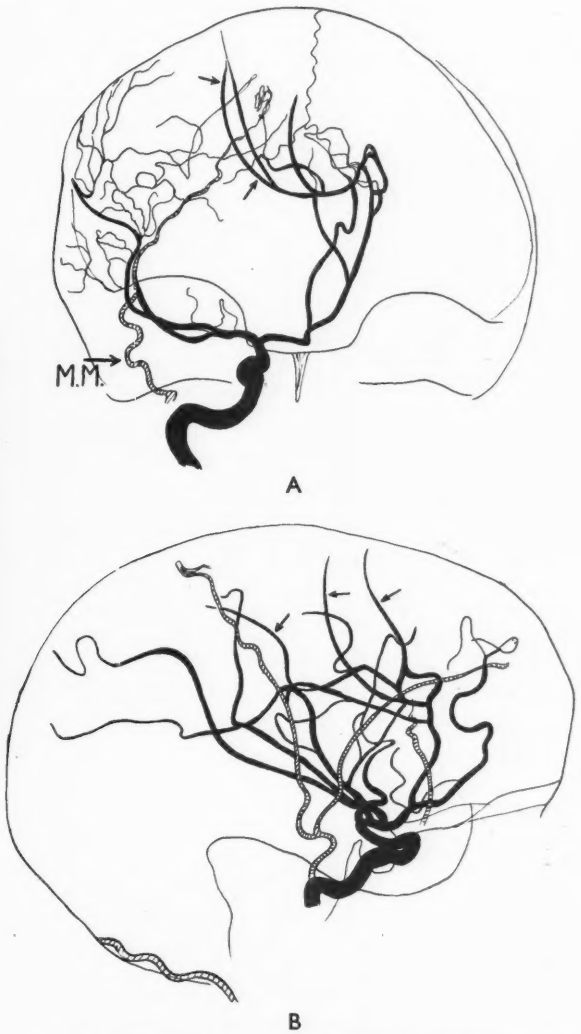


FIG. 497.—Frontoparietal parasagittal meningioma. A, A.P. arteriogram showing the curved displacement of the vessels (↑) around the tumour. The anterior cerebral artery shows its maximal displacement near the falx. The enlarged middle meningeal artery (M.M.) ends in a small tangle of vessels in the region of the tumour. B, Lateral arteriogram showing the curved stretched vessels (↑). The branches of the external carotid artery feeding the tumour are shown (cross-hatching).

The more posterior the tumour the less the shift; sometimes it was absent (*Fig.* 498 A). Generally the shift of the anterior cerebral from the middle line was not so gross as that produced by gliomas.

3. In one tumour situated at the outer end of the sphenoidal ridge, at the Sylvian point, there was no obvious displacement in the lateral projection (*Fig.* 499 B). In the A.P. view the junction of M1 and M2 of the middle cerebral artery was displaced medially and M1 was correspondingly coiled (*Fig.* 499 A). This deformity has not been seen in our glioma series, presumably because these tumours are within cerebral substance either above or below the middle cerebral artery.

4. *Suprasellar meningiomas* showed the same type of displacement as other suprasellar tumours. In 2 cases a circumscribed pathological circulation was also present, which distinguished them from other suprasellar tumours.

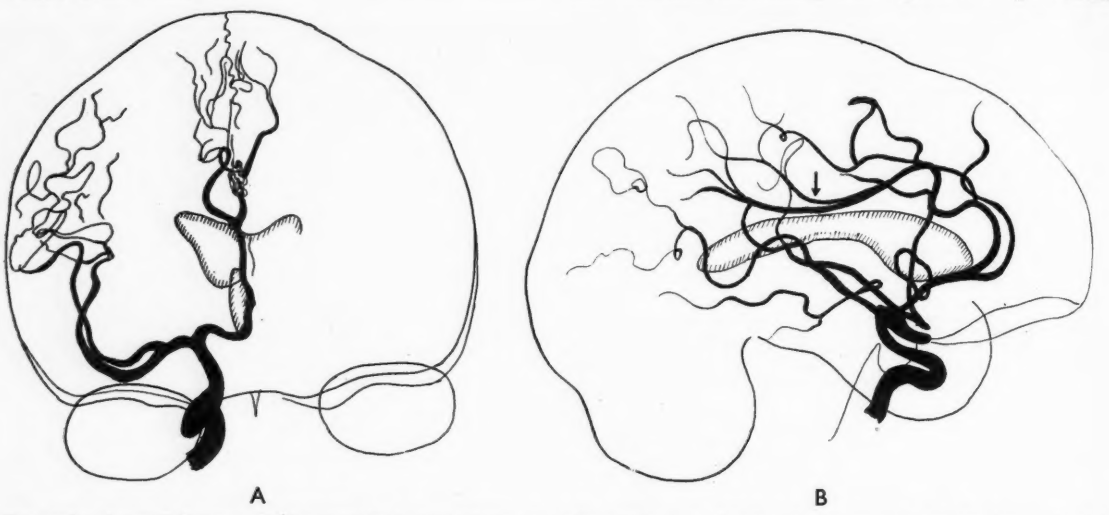


FIG. 498.—A small frontoparietal parasagittal meningioma. A, A.P. arteriogram showing the absence of any displacement of the anterior cerebral from the middle line at A2 and A3. B, Lateral arteriogram showing the downward displacement of A5 of the anterior cerebral (↓). The ventricular outline shows no definite deformity.

5. *Olfactory-groove meningiomas* showed a characteristic deformity. The lateral projection showed a gross upward and backward displacement of A2 and A3 of the anterior cerebral, with squashing of the genu from below (*Fig.* 500 B). This corresponded exactly with the post-mortem findings of Cushing and Eisenhardt (1934). The anteroposterior projection showed a curved displacement of A2 and A3 of the anterior cerebral artery with only slight elevation of A1 (*Fig.* 500 A). However, this curved displacement of A2 and A3 may not be present if the tumour grows symmetrically in the middle line. In such cases the essential diagnostic feature is that the displacement of A2 and A3 (as seen in the lateral picture) is greatly in excess of the displacement of A1 (as seen in the anteroposterior picture).

6. *Sphenoidal-ridge meningiomas*: The characteristic feature, in both lateral and A.P. projections, was the extreme stretching and upward displacement of the terminal part of the internal carotid (C1) and the first part of the middle cerebral (M1) (*Fig.* 501 A, B). The direct effect of the tumour on the artery caused it to be of unusually thin calibre and in one case the passage of contrast was delayed at this point. Not all sphenoidal-ridge meningiomas presented these characteristic displacements, probably because the tumour is apt to vary in its relationship to the carotid and to the sphenoidal ridge. In one case the upper limb of the siphon (C2) was depressed by tumour, whereas C1 and M1 were stretched upwards by tumour tissue below and behind them. Other workers have reported that when the meningioma grows mainly in the anterior fossa

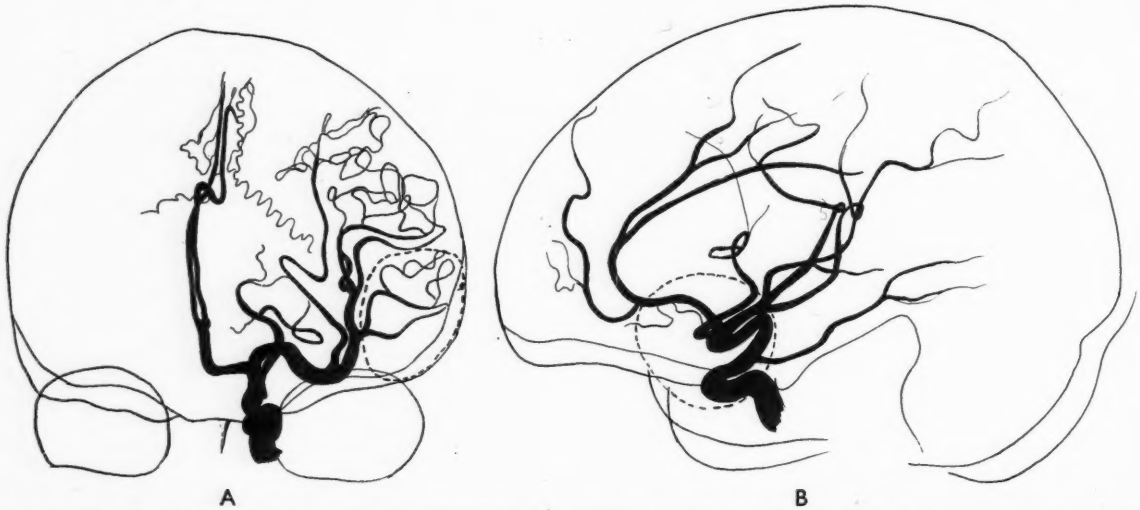


FIG. 499.—A meningioma of the outer third of the sphenoidal wing. A, A.P. arteriogram showing the inward displacement of the middle cerebral group. This is most marked at the Sylvian point. The anterior cerebral is displaced to the right of the middle line but maintains a straight course. The site of the tumour is outlined. B, Lateral arteriogram showing the absence of any definite displacement. The tumour site is outlined.

the angiographic appearances may be those of frontal tumours.

Pathological Circulation.—Egas Moniz, Pinto, and Almeida Lima (1929) first demonstrated by angiography that meningiomas may derive their blood-supply from both the internal and external carotid arteries. Since then various authors have noted the types of pathological circulation which may be found (Fischer, 1939; Hemmingson, 1939; Lorenz, 1940; Engeset, 1944; List and Hodges, 1947; Wickbom, 1948).

In our series of 42 cases the blood-vessels within the tumour were demonstrated in 23. Most of the tumours had an increased vascular supply from branches of the internal or external carotid arteries. In any variety of intracranial tumour the cerebral arteries supplying the tumour may be enlarged and consequently this angiographic sign is rarely of value in pathological diagnosis. But in meningiomas, almost exclusively, branches of the external carotid may also be enlarged and feed the tumour (*Fig.* 502). In 21 of this series of meningiomas there was increased vascularity of cranial branches of the external carotid, and as in 8 of these no tumour circulation could be demonstrated, this finding was important in pathological diagnosis.

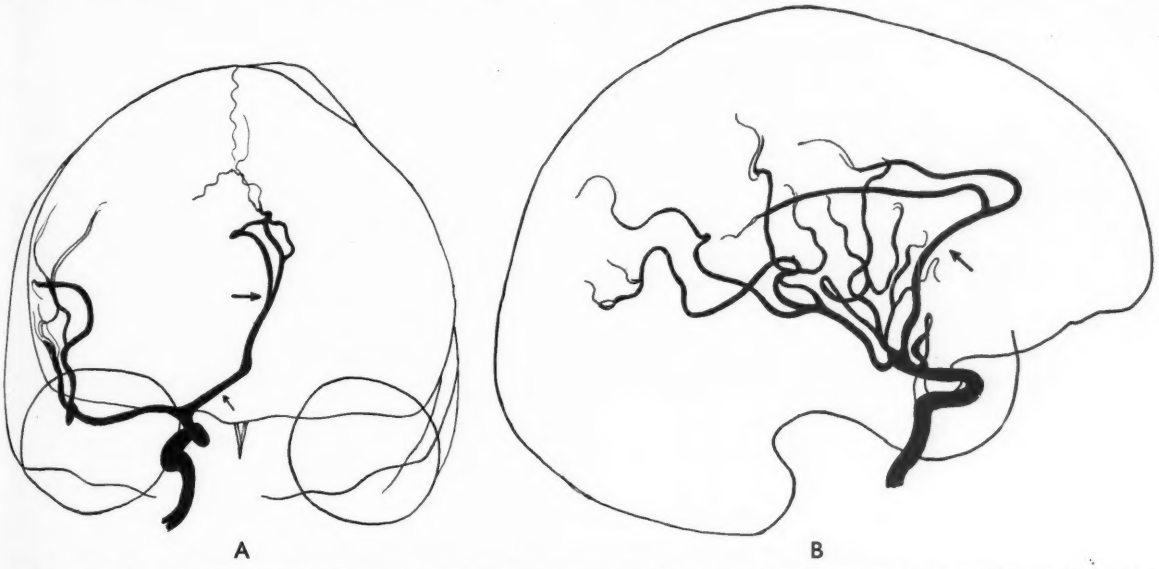


FIG. 500.—An olfactory groove meningioma. A, A.P. arteriogram showing a curved displacement of the anterior cerebral to the left with some upward displacement of A1. In this case the tumour was on the right side. Compare with *Fig.* 506. B, Lateral arteriogram showing the gross upward displacement of A2 and A3 of the anterior cerebral with squashing of the genu from below. Compare with *Figs.* 465, 466.

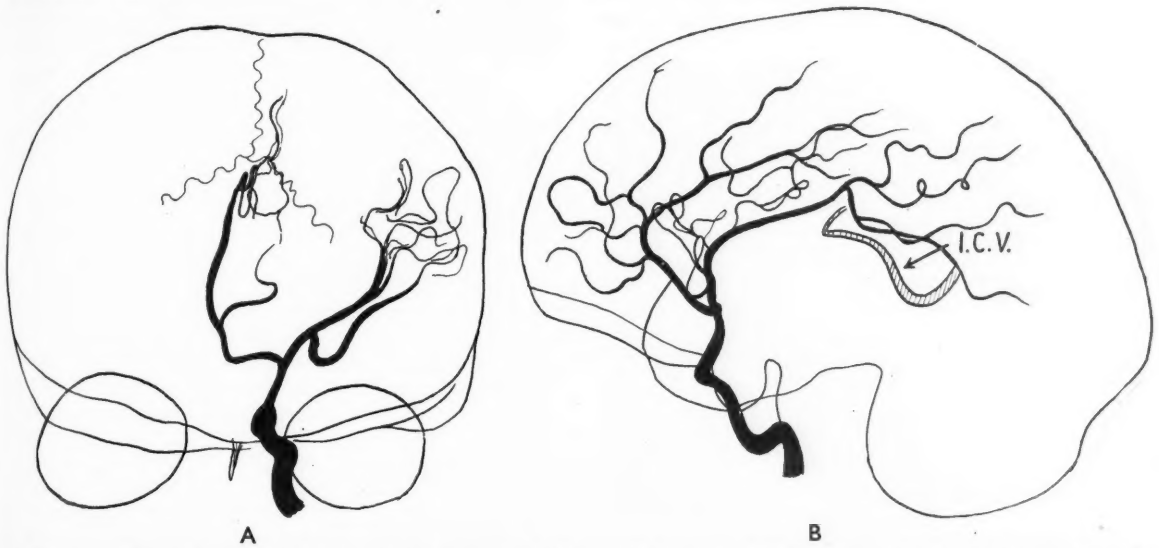


FIG. 501.—The displacement produced by a deep sphenoidal ridge meningioma. A, A.P. arteriogram showing gross upward stretching of the terminal part of the internal carotid and the early part of the middle cerebral. The anterior cerebral is displaced to the right in a slight curve. B, Lateral arteriogram showing the same upward stretching. The siphon is opened out. The internal cerebral vein (I.C.V.) is outlined and is displaced upwards and backwards.

The following types of pathological circulation were seen.

1. A ' capillary blush ', consisting of a fine homogeneous collection of contrast with a fairly sharp outline (*Fig.* 502). This was generally best seen during the capillary or early venous phase, about

3 to 4 seconds from the beginning of the injection; but occasionally it appeared early, during the arterial phase. It was slow in emptying and was often still well marked at 8 seconds.* It could be distinguished

FIG. 502.—The 'capillary blush' in a meningioma following injection of diodone into the external carotid artery. The enlarged middle meningeal (M.M.) and the superficial temporal arteries feeding the tumour are seen.

from a dense angioma by this slow circulation, its more definitely circumscribed border, the absence of grossly dilated venous channels draining it, and the presence of lateral displacement of the anterior cerebral artery.

2. In 3 of 5 histologically verified angioblastic meningiomas there was the appearance of a very

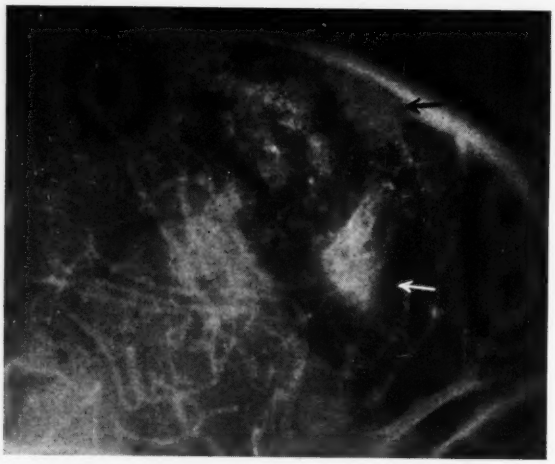


FIG. 503.—Arteriogram in a frontal angioblastic meningioma. There are large irregular patches of contrast (↑) with some vessels of irregular diameter coiled within the area. In spite of the great vascularity no veins were seen in the arterial phase. The irregular patches of contrast are different from those seen in a glioblastoma multiforme (*see Figs.* 488, 490).

vascular tumour of a type different from the others. It consisted of irregular collections of dense contrast, which filled and emptied fairly rapidly (*Fig.* 503). This appearance resembled vascular glioblastoma multiforme, but the pattern was less irregular and bizarre. In one angioblastic meningioma with this picture there was also a sun-ray pattern of vessels.

3. In 5 cases, during the arterial phase, moderately large arteries were seen going into the centre of the dural attachment of the tumour, whence smaller vessels radiated outwards in a star-shaped manner to the periphery, pursuing a wavy course (*Fig.* 504). This appearance has already been described by Almeida Lima (1950). The radiating vessels emptied quickly, within 4 seconds from the start of injection. Seen in profile, the vessels appeared to radiate from a point at the periphery of the tumour which probably corresponded to the centre of the dural attachment. In rapid serial angiograms the radiating vessels were sometimes seen later during the capillary phase.

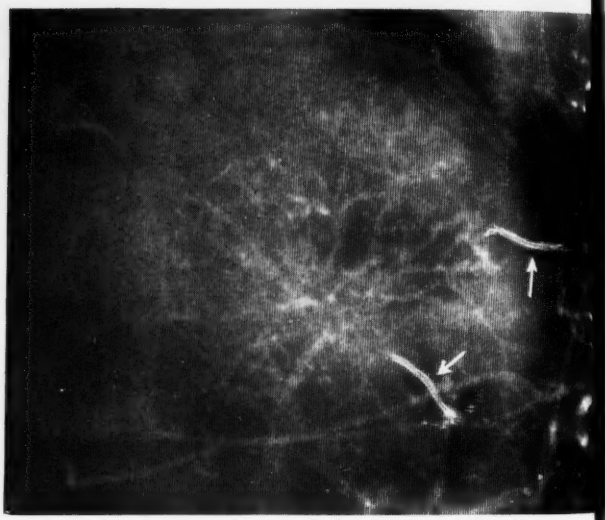


FIG. 504.—Arteriogram showing a 'star-like' arrangement of vessels seen in a vascular meningioma of the Sylvian fissure. The enlarged arteries passing to the centre of the area are indicated. If the attachment of such a tumour to the dura is in a plane at right angles to the projection of the X rays this arrangement may have a 'sun-ray' appearance.

4. The tumour circulation of meningiomas was usually slower than that of glioblastomas. From 6 to 9 seconds after the beginning of injection the tumour circulation was usually no longer visible, and the contrast was then present in veins which surrounded the tumour in a circular manner.

5. *External Carotid Circulation*: Rapid serial angiography has confirmed the findings of Egas Moniz (1934) that the internal carotid circulation is normally faster than the external. In meningiomas the external carotid circulation is usually as fast as the circulation of the internal carotid. Of our 42 cases 21 showed early filling of an enlarged middle meningeal artery (*Fig.* 505). Eight of these showed no other evidence of pathological circulation. If the enlarged middle meningeal ended in a small tangled knot of vessels it was strongly indicative of a meningioma, as was noted by List and Hodges (1947) (*Fig.* 505). Enlargement of the branches of the superficial temporal was not reliable as there is great normal variation in their size.

GROUP D. CEREBRAL ABSCESS

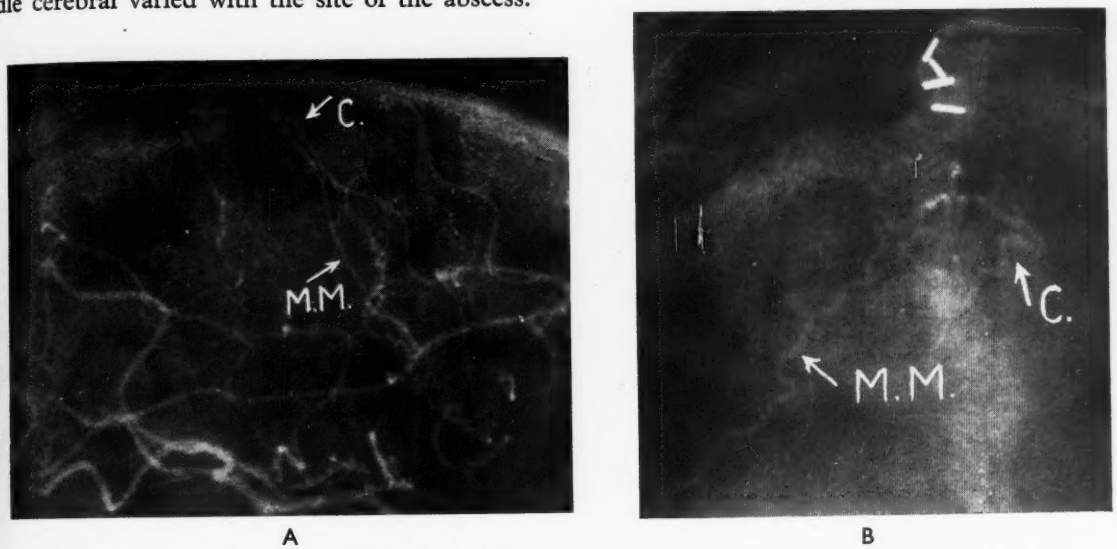
There were 13 cases—Temporal 8, Parietal 3, Frontoparietal 2. None of these abscesses showed any pathological circulation or dilatation of vessels.

* All timing mentioned in this section refers to the time elapsed from the beginning of the injection.

1. Temporal.—Temporal abscesses showed the same general features as astrocytomas of the temporal lobe with certain variations. The lateral projection was similar to that found with temporal or temporo-occipital astrocytomas (*see Fig.* 486 B). In the A.P. projection the shift of the anterior cerebral was usually not so gross as with gliomas of the same site, but had the same shape. The displacement of the middle cerebral varied with the site of the abscess.

GROUP E. PITUITARY TUMOURS
(7 Cases)

In no case was a pathological circulation demonstrated. The particular vascular displacements produced by pituitary tumours depend on the common suprasellar extension of the tumour. If the tumour extends into the frontal or temporal lobe the displacements are correspondingly altered.



A B

FIG. 505.—Examples of the middle meningeal artery (M.M.) ending in a small clumped vessel (C) over a meningioma. B was a case of recurrent meningioma.

If the abscess was situated anteriorly (2 cases) M1 was elevated, and in the A.P. projection ran obliquely upwards and outwards, forming a continuous straight line with M2 (*Fig.* 485 A). When the abscess was situated more posteriorly (6 cases) this linear displacement was not observed (*Fig.* 486 A).

2. Parietal.—In one case there was no definite abnormality in the lateral projection. In the A.P. projection the anterior cerebral artery showed a straight lateral displacement, but there was no abnormality of the middle cerebral. In the other two cases, one of which had bilateral small abscesses, there was no definite abnormality noted in either projection.

3. Frontoparietal.—The two cases showed the usual characteristics of an avascular tumour in the same region.

In our series the precise size of the abscess in most cases has been demonstrated by thorotrast pyograms (Tutton and Shepherd, 1949). The abscess was always somewhat smaller than the angiographic displacement suggested, probably owing to œdema of the surrounding brain, but partly also because the abscess had been aspirated before pyography.

Thus, angiography has only been of decisive value in the abscesses of this series when the abscess was situated in the temporal lobe. Our experience does not support the recommendation of Fabritius, Frøvig, and Kristiansen (1949) that repeated angiography is preferable to thorotrast pyography in following the progress of a cerebral abscess.

The Anteroposterior Projection.—The most definite changes were seen in this view. The coiled part of the carotid siphon was displaced laterally in only 1 case, probably because its course within the dura makes it relatively immobile. C1 showed a varying degree of stretching and displacement laterally, depending on the size of the tumour. If the tumour grew upwards and forwards, A1 of the anterior cerebral was displaced so that it ran obliquely upwards and medially instead of taking its normal horizontal medial course. With further extension of the tumour forwards A2 shared in this (*Fig.* 506); but, contrary to the findings with olfactory-groove meningiomas, the main incidence of displacement was on A1. The angle between the internal carotid and anterior cerebral arteries was always at least 90° and generally more (*Fig.* 506), in contrast to the normal angle, which is less than 90°. The bifurcation of the internal carotid was raised and this necessarily raised the origin of the middle cerebral; unless the tumour extended into the temporal lobe the more lateral part of the middle cerebral was not disturbed.

The Lateral Projection.—The changes were not gross in most cases. With lateral and posterior extensions C2 and C1 were stretched upwards, and in one case gave an appearance rather similar to that produced by a sphenoidal-ridge meningioma, but the displacement was not so gross. In no cases did C3 and C4 appear to be distorted. In one tumour, which at autopsy had mainly extended upwards and backwards into the third ventricle, the internal cerebral vein in the phlebograms was displaced backwards and upwards. In this case C1 of the internal carotid was stretched upwards, but the anterior cerebral showed

no obliquity in the A.P. projection but ran at a higher level, corresponding to the absence of gross forward extension of the tumour. In tumours situated more anteriorly A2 and A3 of the anterior cerebral were elevated, with squashing of the genu from below (*Fig.* 506). This effect was similar to that produced by the olfactory-groove meningiomas in the lateral projection, but the displacement of A1 in the A.P. differentiated them (cf. *Figs.* 500, 506).

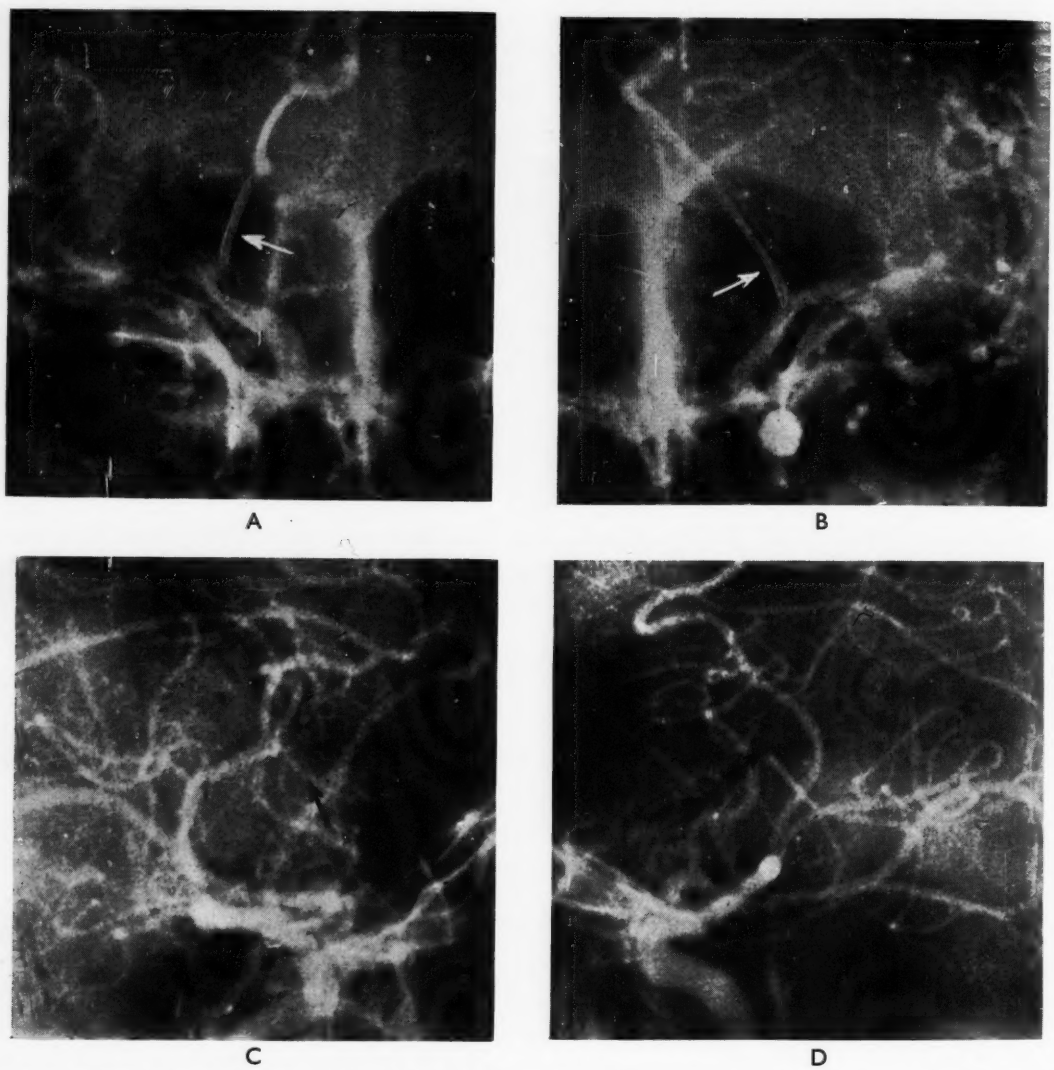


FIG. 506.—Right and left A.P. and lateral arteriograms of a suprasellar pituitary adenoma which has extended forwards. A, B, In both A.P. views A1 of the anterior cerebral is pushed up and A2 runs obliquely. C, D, In both lateral views A2 and A3 are pushed up with squashing of the genu from below. Compare with *Fig.* 500.

DISCUSSION

In this paper I have reviewed our experience at Oxford of over 700 carotid angiographic studies with particular reference to intracranial tumours and other space-occupying lesions. In addition, 94 cases with normal angiograms have been studied by the 3-film or rapid serial method (Curtis, 1949), to gain a detailed knowledge of the appearances of the normal angiogram.

No consideration has been given here to vertebral angiography; I have found that the percutaneous technique as used by Sugar, Holden, and Powell (1949) is in most cases practicable, but further experience is required to estimate its value in diagnosis. Meanwhile, with the carotid route, angiography has its greatest value in the diagnosis of tumours of the cerebral hemispheres, and especially with tumours of the anterior two-thirds of the hemisphere. Tumours of the posterior third of the cerebral hemisphere not only lie away from the main branches of the internal carotid, upon the displacement of which angiographic diagnosis so largely depends, but they are also frequently, in whole or in part, within the vascular zone supplied by the posterior cerebral artery.

Details have been given of the angiographic appearances of different types of tumour in different situations. There are also certain general considerations which must constantly be borne in mind. Good films are essential and to this end the technique of puncture, of injection, and of positioning requires constant practice by an unchanging team.

The interpretation of films should be carried out systematically. The first step is to determine whether the skull has been accurately positioned and the tube accurately centred, and, if the projection is not a true one, to make allowance for the resulting effect of parallax upon the position of the vascular images. It must be remembered that variations in the position of the central ray of the tube will effect the position of the bony landmarks by which a true projection is judged (*Fig.* 447).

The next step should be to study the antero-posterior projection. The most important general sign produced by hemisphere tumours is a lateral displacement of the anterior cerebral artery from the middle line. This lateralizes the lesion. The normal deviations of the anterior cerebral artery to one side or other are never gross and retain the normal curled appearance of the vessel; and they frequently involve both sides in different parts of their course (Wickbom, 1948; also *Figs.* 468 and 472 of this paper). Normal variations are usually localized, whereas pathological displacement almost always involves the whole of the anterior cerebral lying below the falx, and the artery loses its coils and appears stretched. Probably the minimal degree of displacement necessary to diagnose a space lesion is seen in *Fig.* 507 A.

The shape of the displacement of the anterior cerebral is most valuable in localization and has received insufficient attention. Fischer (1938) noted the type occurring in frontal tumours and found it important. List and Hodges (1946, a) and Wickbom (1948) describe the appearance produced in different tumours, but do not remark on its important localizing value. Egas Moniz and his colleagues appear to have placed little reliance on the A.P. projection. In our series we have found that if the artery is markedly curved the tumour is frontal, whereas if the artery is only slightly curved the tumour is frontoparietal. Occasionally this may be the only unequivocal localizing sign. If the displacement is straight, with an abrupt return to the middle line in its upper part, the tumour is either temporal, parietal, or occipital, and the precise diagnosis depends on the presence or absence of elevation of the middle cerebral artery and the other signs already described. In my experience the only tumours which have shown no displacement of the anterior cerebral have been situated either in the basal ganglia, or in the parieto-occipital or posterior parasagittal areas, but some of these show a lateral displacement of the internal cerebral vein. It must be remembered that conditions other than tumours which produce a ventricular shift may also produce a shift of the anterior cerebral to or from the side of the lesion. These include subdural and extradural hæmatomas, cerebral atrophy, and scarring. Bifrontal tumours, as might be expected, frequently produce a minimal lateral shift.

The next step is to study the lateral projection. The most important sign in the lateral projection is displacement of the Sylvian group of vessels. Upward displacement indicates a tumour of the temporal lobe or middle fossa. It is distinguished from the normal (*Fig.* 461) by the fact that all the vessels in the Sylvian fissure are displaced together, and they tend to have an arched stretched course. The minimal requirements to diagnose a temporal lobe tumour are shown in *Fig.* 507 B. If the tumour is deep, such as a cavernous sinus meningioma, it lies near the proximal part of the middle cerebral and the terminal intradural part of the internal carotid. Then these parts are elevated and stretched and the siphon is opened (*Fig.* 501). However, tumours lying low in the middle fossa may produce no obvious changes; in such cases a pneumographic study of the temporal horns (Lindgren, 1948) may prove much more valuable.

Apparent depression of the Sylvian group has no significance unless it involves all the vessels lying in the fissure and these appear stretched. The interpretation can be checked from the fact that tumours which depress the middle cerebral artery also cause a characteristic shift of the anterior cerebral in the A.P. projection.

In certain regions the diagnosis may depend on minor changes in large vessels; for example, in the

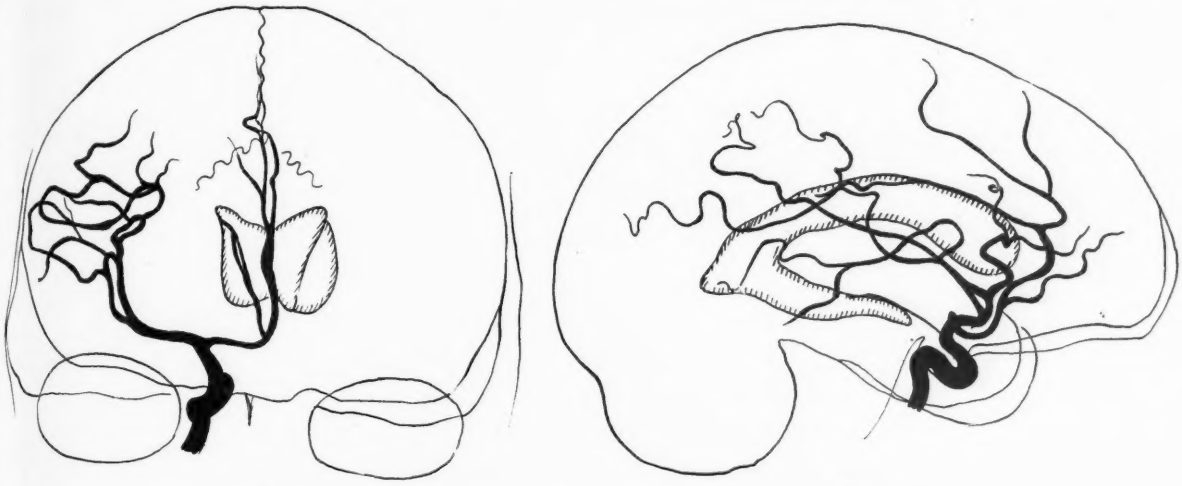


FIG. 507.—Minimal displacement of arterial vascular tree with a diffuse infiltrating astrocytoma of the temporal lobe. A, A.P. arteriogram. There is slight but definite lateral displacement of the anterior cerebral and of the ventricles. The middle cerebral group shows slight stretching and M2 shows more of its course than usual, indicating that it is slightly elevated. B, Lateral arteriogram. There is slight elevation of the middle cerebral at M2, and slight deformity of the inferior horn of the lateral ventricle.

suprasellar and posterior parasagittal regions, as has already been described. In general, minor changes in one projection should be confirmed by changes in the other projection; otherwise pneumo-encephalography should be employed.

A pathological circulation helps in localization. In this series it was demonstrated in 75 per cent of meningiomas, in 75 per cent of the glioblastomas, and in less than 2 per cent of astrocytomas. It has been seen in rapid serial angiograms in cases in which it was not shown by the 3-film method. It is important not to overlook signs which indicate that the tumour extends farther than the pathological circulation indicates (*Fig.* 480 B).

The phlebograms have their greatest value in showing pathological circulation. Little reliance can be placed on the position of the normal surface veins, including the superior and inferior anastomotic veins, owing to their inconstant site and appearance; but normal veins pursue a slightly wavy course and if this is lost and the vein runs in a large stretched curve a tumour should be suspected.

The appearance of the internal cerebral vein is often of great value in diagnosis as it runs a constant course in the roof of the third ventricle. At its anterior end it curls back and this accurately marks the site of the foramen of Monro. Hydrocephalus involving the third ventricle causes the internal cerebral vein to be arched upwards and backwards. Tumours invading the third ventricle, such as suprasellar pituitary tumours, may also elevate it. Frontal tumours generally displace the site of the foramen of Monro backwards. Lateral displacement of the internal cerebral vein should always be looked for in the A.P. phlebogram as it is of great lateralizing value if present, particularly if there is no shift of the anterior cerebral artery.

Frontal, Rolandic, and temporal tumours are localized accurately in a high percentage of cases. Parietal tumours are much more difficult, particularly if they are deep; some in our series have not shown the features described by Wickbom (1948).

From the angiographic point of view intracranial tumours of the hemispheres fall roughly into two types—the vascular and the avascular. If a tumour is vascular it may be a glioblastoma multiforme, a meningioma, a metastatic tumour, or one of the rare types of astrocytoma with abnormal vessels. The differential diagnosis depends on the type of pathological vessels, as described in the previous section. If a tumour is avascular it is most commonly an astrocytoma, but it may be a necrotic or cystic glioblastoma multiforme, a meningioma, a metastatic tumour, or an abscess. Avascular meningiomas may show characteristic features of vascular displacement which have been described. Avascular metastatic tumours have no special characteristics, except that they are generally small and may be multiple. The pre-operative diagnosis of an abscess rests almost entirely on clinical grounds, but may be assisted by angiography.

In conclusion, the interpretation of cerebral angiograms is still far from perfect, and it is to be anticipated that much greater precision will be attained with increasing experience. With practice finer changes in the less easily demonstrated vessels, as for example the internal cerebral vein, can be interpreted with an increasing degree of accuracy. In this connexion the educational value of rapid serial angiograms to any worker in this field is worthy of consideration.

SUMMARY

1. The percutaneous technique of carotid angiography, its complications, and the complications of the use of diodone, have been described.

2. Over 700 carotid angiograms which have been carried out in this Department have been reviewed with especial reference to the appearances in the normal subject and the alterations produced by intracranial tumours.

I wish to thank Professor Sir Hugh Cairns for his constant encouragement and advice during the last three years while I have been working on this subject and for his great care and patience in assisting me in the preparation of this paper. I wish to thank also my medical colleagues who have assisted me with the angiographic examinations, and especially Dr. Cesar de Freire Andrade. I am grateful to the staff of the Radiological Department of the Radcliffe Infirmary, in particular to Miss D. Haigh, Miss A. Goodliffe, and Mr. A. Nicholls, for their help; to Miss Audrey Arnott for her careful reproduction of the numerous tracings; and to Mr. Peter Schurr for correcting the proofs.

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EXPECTANT TREATMENT OF PYOGENIC INFECTIONS OF THE HAND

WITH SPECIAL REFERENCE TO INFECTION OF THE FLEXOR ASPECT OF THE FINGERS

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THE main object of this paper is to advocate a more conservative attitude in the treatment of infections of the hand. If it can be established that conservative treatment in the initial period of infection is not only safe but desirable, then the general practitioner can without fear treat these infections in his own practice.

Hand infections are responsible for just under a half of the attendances at the Septic Clinic at the Victoria Infirmary. Admissions to hospital beds are few. Only one hand infection was admitted to hospital from the clinic during the periods under review. Three cases admitted directly to the wards are included.

Many factors have contributed in recent years to the great improvement which has been manifest in the limitation of spread of infection in the hand, and in the functional results achieved. Propaganda and prophylaxis have played their part, but probably the greatest single factor in this improvement is the introduction and use of penicillin. Another factor which, in the writer's opinion, is of supreme importance is the type of local treatment applied.

NOMENCLATURE

Some confusion in discussion of hand infections has arisen owing to the introduction of a great profusion of names and classifications. For the purpose of this paper, all infections of the flexor aspect of the finger are divided into these categories :—

a. Pulp infections: This term is applied to infections which primarily involve the soft tissue overlying the flexor aspect of the terminal phalanx.

b. Flexor cellulitis: Under this heading are included all infections primarily involving the soft tissues overlying the flexor aspect of the proximal two phalanges, and it includes infections of the flexor tendon-sheath. The grouping of superficial and deep infections under the same heading is done advisedly, because, despite earlier teaching to the contrary, it is not always easy to decide on clinical examination whether the tendon-sheath is infected or not. The use of this term was encouraged as the conservative treatment of finger infections was being adopted. No differences in treatment were applied, even although clinically it was felt that the infection

had penetrated to the tendon-sheath. All infections of the proximal two compartments of the finger were treated identically until localization had occurred, and only when incision to drain a localized collection of pus had been carried out could the exact depth be determined.

BACTERIOLOGY AND MODE OF INFECTION

It is not proposed to discuss the bacteriology in this paper, apart from stating that over 90 per cent of these infections were caused by strains of *Staph. aureus* which were penicillin-sensitive. In the vast majority of the cases discussed here, the infection was either unrelated to known trauma, or followed on definite but minor injury. Cases of gross injury to the hand or fingers are not included.

PATHOLOGY OF PULP INFECTIONS

By adopting a conservative line of treatment in all hand infections, the opportunity has arisen to observe the natural course of such infections, or, at least, the course modified by the action of penicillin, but not interrupted by early surgical intervention. Infection of the pulp commences as a soft-tissue cellulitis, and, if left to its own devices, gradually localizes, with the formation of a tough slough which is situated at the point of maximum incidence of the infection. This slough softens with the formation of pus, and the abscess so formed will point centrally, terminally, or laterally in the pulp. A high proportion of pulp infections, if seen early and treated with penicillin together with local heat and rest, will resolve completely without requiring any surgical intervention. (*Table I.*)

Table I.—Fate of Pulp Infections and Cases of Flexor Cellulitis (Excluding Tendon-sheath)

	Pulp	Flexor Cellulitis
Total cases	431	228
Cases resolving without operation or spontaneous discharge	101 (23 per cent)	77 (34 per cent)

Localization with pus formation, or complete resolution, usually occurs in from 4 to 8 days.

Infections in the pulp may spread to involve the phalanx or the terminal part of the tendon-sheath. Where the latter occurred in this series, the case has been considered as a flexor cellulitis with tendon involvement.

If the slough formed in the course of a pulp infection is removed after being separated largely by natural means, it leaves a clean cavity which is quickly obliterated by re-expansion of the surrounding normal tissue and by healthy granulations. Tension in pulp infections has often been blamed for causing sequestration of the shaft of the terminal phalanx. The tension was said to cause obliteration of the terminal vessels running to the bone from the laterally placed digital arteries. These vessels traverse the pulp in their course. If such were the true state of affairs, then increasing density of the shaft of the phalanx would be the radiological evidence of this ischæmia. Such evidence is not forthcoming. The true picture is illustrated in *Fig.* 508. This shows osteoporosis associated with hyperæmia of the adjacent acute inflammatory process, followed by a return to normal density as the hyperæmia subsides. In the case illustrated, the tip of the phalanx has been destroyed by direct infection. The blame for sequestration of the shaft of the terminal phalanx, which frequently followed the making of early lateral incisions into the tense pulp, was laid too often on tension and not often enough on the surgical trauma. These incisions either directly damaged the blood-vessels, or put the additional strain of attempting to heal a wound on to a blood-supply already stretched to its limit in the endeavour to repel bacterial invasion.

Direct extension of the infection to the bone, and loss of blood-supply caused by thrombosis due to staphylococcal toxins are also causes of death of bone.

These observations are largely in accordance with the views expressed by Professor Pilcher (Pilcher, Dawson, Milstein, and Riddell, 1948).

PATHOLOGY OF TENDON-SHEATH INFECTIONS

Only the group of cases of flexor cellulitis in which the tendon-sheaths are involved are discussed here, as those infections superficial to the tendon-sheath are similar to soft-tissue infections elsewhere, and require no special description.

Infection of a tendon-sheath has been held to be an indication for immediate surgery. This was based on the belief that, once infection penetrated to the sheath, it spread rapidly to the limits of the sheath. The barriers to the spread of infection were thought to be largely anatomical. It was further assumed that the tension in the sheath could rise to such an extent that the tendon would be deprived of its blood-supply. Iselin (1933) accepted that view, and advocated opening the sheath of the fingers at its proximal end.

It seems highly improbable that in a natural defence mechanism the tissue tension would, or could, ever be raised to a pressure above that in the vessels on the arterial side of the capillary lake. The latter is the force producing the tissue exudate. Loudon, Miniero, and Scott (1948) have aspirated fluid from the distal extremity of the sheath, and shown it to contain pus cells and bacteria. This has been cited as evidence of infection throughout the length of the sheath. If cases of tenosynovitis are treated conservatively, at least in the initial stages, then a truer picture of the probable course of events is obtained. The clinical picture suggests that, following upon the entry of infection into the sheath, there is an immediate response by a widespread effusion. There is swelling and tenderness along the line of the sheath, together with limitation of function. Next, the layers of the synovia become adherent around the point of entry of the infection, the effusion in the sheath is partially absorbed, and, around the site of entry, the usual inflammatory barrier to the spread of infection is built up. This barrier spreads out from the level of the sheath to the more superficial tissues, and eventually involves the skin. If the defence mechanism is weak, then the barrier remains broad and ill-defined, and may spread from the site

of infection both proximally and distally. If the defence is adequate, then the barrier becomes narrow and well defined. The clinical evidence of the latter outcome is that the area of redness, swelling, and tenderness becomes localized and finally may show central pus formation—pus which will eventually be extruded through the skin on the palmar surface of the finger, and usually near the level of the proximal or distal interphalangeal joint. *Fig.* 509 is an attempt to illustrate this diagrammatically. As localization occurs, the signs of infection in the sheath, proximal and distal to this point, disappear, and function improves, although there is still pus in part of the sheath. Now is the time for surgical intervention, when the road to the surface has been well shut off by the inflammatory barrier. If this abscess is opened by removing the anterior wall and all necrotic tissue is cleaned out, it will be found that the anterior wall of the fibrous tunnel and of the synovial sheath have been removed, and the tendon lies exposed in the floor of the abscess (*see Fig.* 511 C). That the cavity of the sheath has been closed proximally and distally can be readily demonstrated by attempting to pass a probe. The probe is arrested at the level of the abscess wall where the layers of the sheath have become firmly adherent. The synovial sheath has responded to infection, as does the pleural or peritoneal cavity. In each case there is an initial widespread effusion, which is mildly purulent, but in each case, given time, the infection will localize.

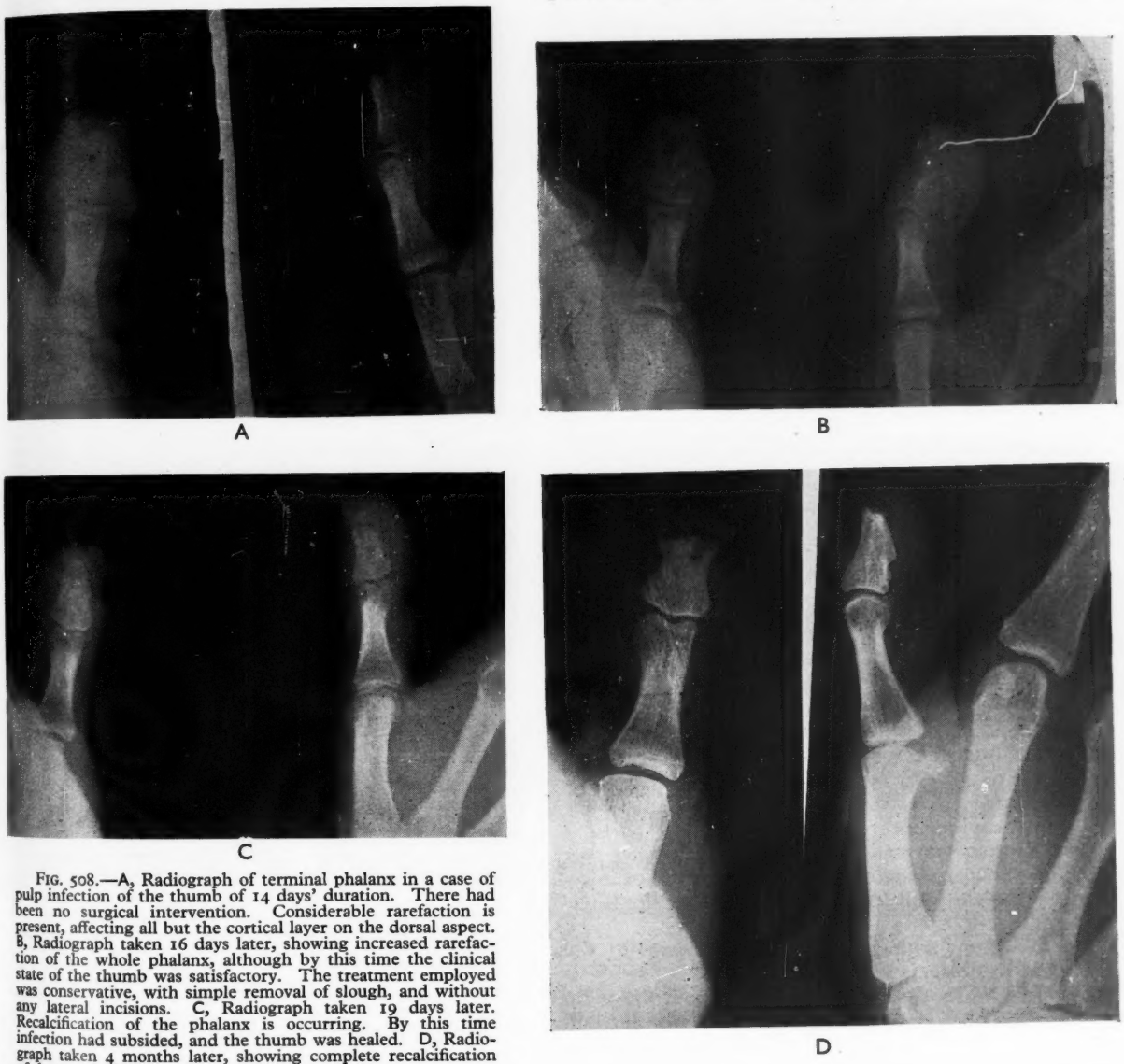

FIG. 508.—A, Radiograph of terminal phalanx in a case of pulp infection of the thumb of 14 days' duration. There had been no surgical intervention. Considerable rarefaction is present, affecting all but the cortical layer on the dorsal aspect. B, Radiograph taken 16 days later, showing increased rarefaction of the whole phalanx, although by this time the clinical state of the thumb was satisfactory. The treatment employed was conservative, with simple removal of slough, and without any lateral incisions. C, Radiograph taken 19 days later. Recalcification of the phalanx is occurring. By this time infection had subsided, and the thumb was healed. D, Radiograph taken 4 months later, showing complete recalcification of the terminal phalanx, except for extreme tip.

TREATMENT

Discussion of Principles.—Until very recent years, the treatment of hand infections was based upon the teaching of Kanavel (1939). The principles of his teaching were three in number: First, that the barriers to the spread of infection in the hand were largely anatomical, and not temporary ones erected by the defence mechanism. The second principle was that incision should be early in the finger, even before pus had formed, so that tension

could be relieved. This principle has been supported by Webster (1947). The soundness of these two principles has been questioned in the foregoing discussion on the pathology and clinical course of these infections. The third principle of this teaching was that incision in the finger for sheath infection should

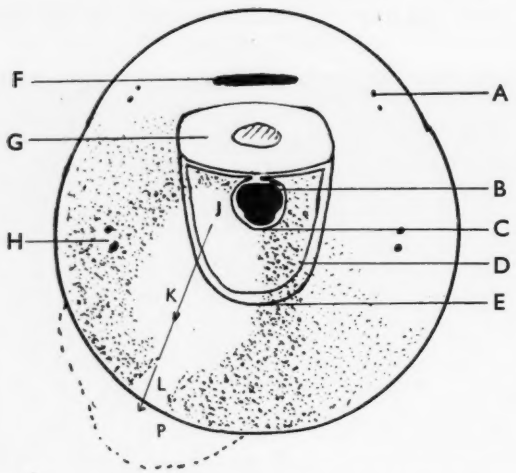

FIG. 509.—Transverse section of finger showing diagrammatically the course of infection in a tendon sheath. After initial widespread effusion in the sheath the parietal and visceral layers become adherent around the point of maximal infection (J). As suppuration takes place the inflammatory barrier guides the pus to the surface. A, Dorsal vessels and nerve; B, Flexor tendon; C, Visceral layer of synovia; D, Parietal layer of synovia; E, Fibrous sheath; F, Extensor tendon; G, Phalanx; H, Palmar vessels and nerve; J, Point of infection in synovial sheath; K, Track of escaping pus; L, Neck of collar-stud abscess; P, Purulent blister. The stippling represents a well-formed inflammatory barrier.

be placed laterally rather than on the palmar aspect. These palmar scars were accused, at the worst, of herniation of the tendon, and, at best, of becoming tender, contracted, and adherent. It was also stressed that these incisions should be accurately placed, so as to avoid the palmar digital vessels and nerves.

What does this lateral incision actually do?

a. It provides indirect drainage.

b. It often traverses, first uninfected tissue, then the inflammatory barrier, and finally the site of infection. This can only encourage spread of the infection. (*Fig.* 509.)

c. It often damages the very vessels it was designed to preserve.

d. In passing sinus forceps across the front of the phalanx to open the sheath, the sheath is partially destroyed, the periosteum is irritated or torn, and the vinculæ carrying the blood-supply to the tendon are ruptured. The late result of this is that, with healing, the tendon becomes adherent to the anterior aspect of the phalanx for a distance of perhaps ½ in., sufficient to prevent even the powerful flexors from levering it free.

e. It is not always easy to diagnose tendon-sheath infections, and, if some anatomical method of approach is adopted, a tendon-sheath may well be opened when, in fact, the infection was superficial. Not infrequently, an abscess of finger is opened in the belief that the infection has arisen in the synovial sheath, only to find that the purulent collection originates between the synovial sheath and the fibrous tunnel, or even superficial to the tunnel.

f. Finally, the lateral incision loses much of its attraction when most of the evils ascribed to palmar incisions and scars are found to be unwarranted. *Figs.* 510–512 illustrate this point.

Thus criticism can be levelled at all three principles of the teaching that advocated early surgery in these infections. What principles can be adopted, now that the help of penicillin is available?

First, it should be borne in mind that the real objective of the defence mechanism is localization. The patient gets relief only when the infection has ceased to spread. This can be observed in the

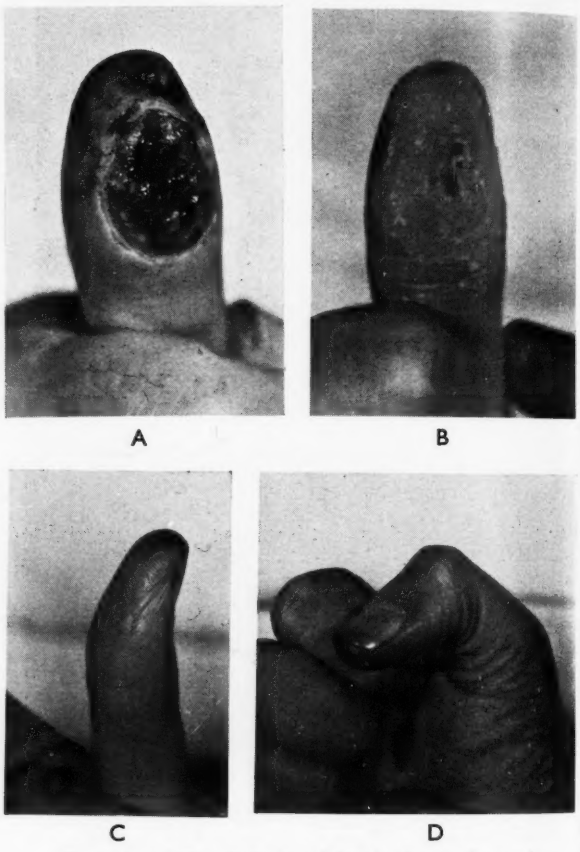

FIG. 510.—A, Pulp infection of thumb, showing 'saucerization' method of opening the pulp after complete localization had occurred. B, Same case, 4 weeks later. The thumb had healed 10 days prior to this, and the patient had returned to his job as a school-teacher. C, D, Same case, 16 months later, showing a well-healed non-tender scar in a pulp only slightly flattened. Full function is present.

patient who, although he still has a big collection of pus in his tissues, declares that pain has gone and function is returning.

Secondly, surgery has no part to play in the treatment of active spreading pyogenic infection in the hand, but should only come in as the scavenger to clear up the debris of the battlefield after the fight has been won by the defences. Early incision for a cellulitic indurated lesion does harm by damaging tissue, which, thus devitalized, affords an excellent repast and a fertile breeding ground for the invader. The defences are also weakened by adding to the burden of an already overtaxed blood-supply the demand that an attempt should be made to heal an unnecessary wound. Any action which deprives the

infected tissue of blood-supply, or which would damage the natural barrier to the spread of the infection, is not logical and is to be avoided.

Thirdly, when drainage is to be established it should be direct.

Method.—With these principles in mind, the method of treatment to be described has been used since March, 1947. It has been employed in all finger and hand infections, including tendon-sheath infections. In cases where bone has been involved, no special surgical intervention has been undertaken, and only clinically and radiologically obvious sequestra have been removed. This method has the outstanding merit of being simple, requiring no special surgical facilities. It consists essentially of expectant treatment backed by penicillin until either complete resolution occurs or until a well-defined abscess has formed. One of the outstanding reasons for adopting this line of treatment is that, as already stated, a not inconsiderable proportion of these cases resolve without discharge of pus. (*See Table I.*)

These cases are all treated as out-patients. If, when first seen, the lesion is active, with spreading infection of a cellulitic character, then the patient is put on a course of parenteral penicillin. The aqueous solution has been used throughout. The cases are seen daily, or at less frequent intervals, and the length of the penicillin course is judged solely by the clinical state. The course, therefore, may last from 2 to 10 days or more, and the dose vary from 250,000 to 1,000,000 units twice daily. Lymphangitis and lymphadenitis are considered specific indications for penicillin therapy. The course is usually continued for 48 hours or longer after incision, should the latter be required. Sedatives are of value during this period of treatment.

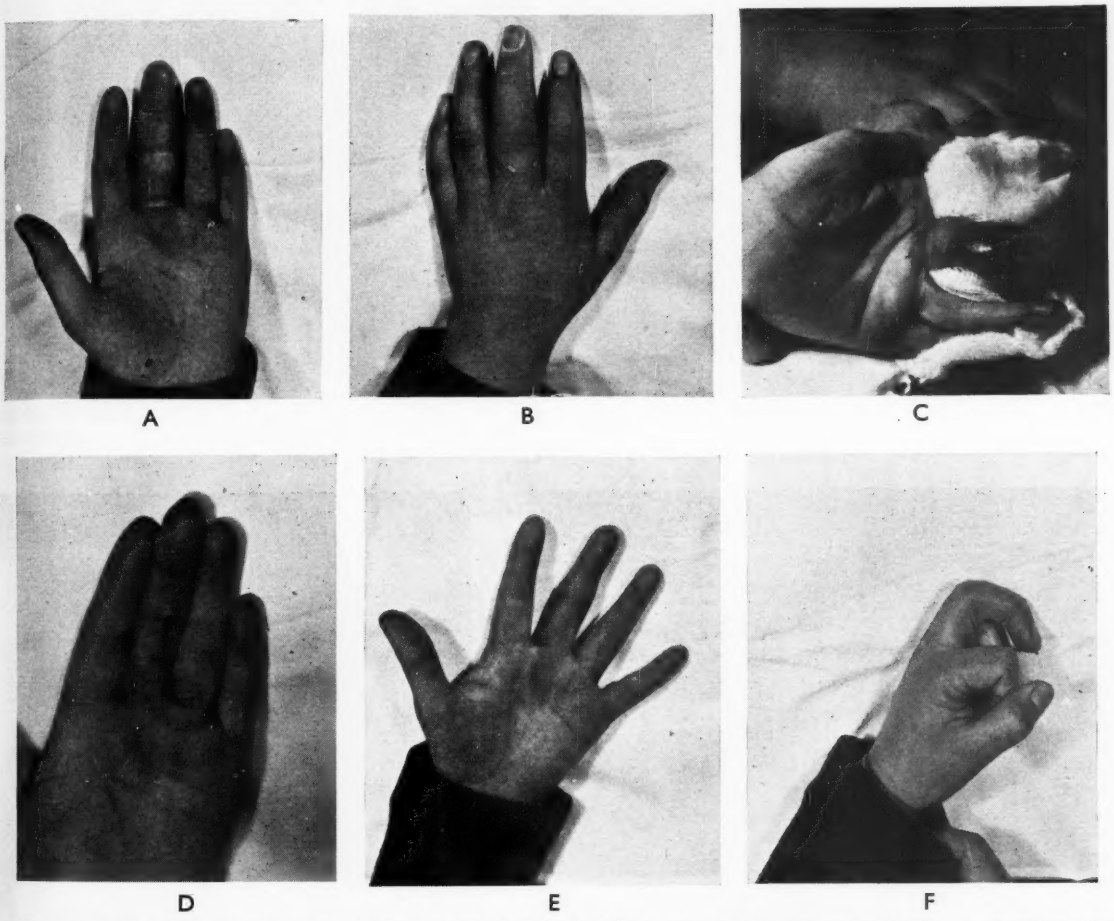

FIG. 511.—Case of suppurative tenosynovitis treated initially by local heat and rest and parenteral penicillin. A, B, Show palmar and dorsal aspects of middle finger with localization over the proximal interphalangeal joint. C, Shows the abscess opened by removing the outer wall. Tendon lies exposed in the depths. D, The same case 4 weeks later. The wound is already healed, and the patient had returned to work as a bus conductress. E, F, Show the finger 11 weeks after operation. The scar is well healed and function is good.

The local treatment consists in applying kaolin or similar ' dry ' type of poultice to the finger, or even to the whole hand. Kaolin is not only a useful form of applying heat, but it makes an excellent splint for the finger and hand. A sling should also be employed. It is considered essential that no wet dressing of the hot fomentation type should be used. Pyogenic organisms delight in a moist ' atmosphere '.

In the course of 2 to 4 days after initiation of treatment, and this usually means about a week after the onset of the infection, localization occurs. This will be followed by complete resolution, or by the pointing of pus at the site of localization. Both these events should be regarded in the same light. They are the expression of the fact that the defences

have overcome the infection. All activity and spread have ceased. In both events, the general condition rapidly improves. Widespread pain has disappeared, although localized pain and tenderness may remain

Lately, however, such collections occurring in the fingers and palm have been left, and allowed either to discharge spontaneously, or to be aided in the final eruption by snipping the dead skin as part of the

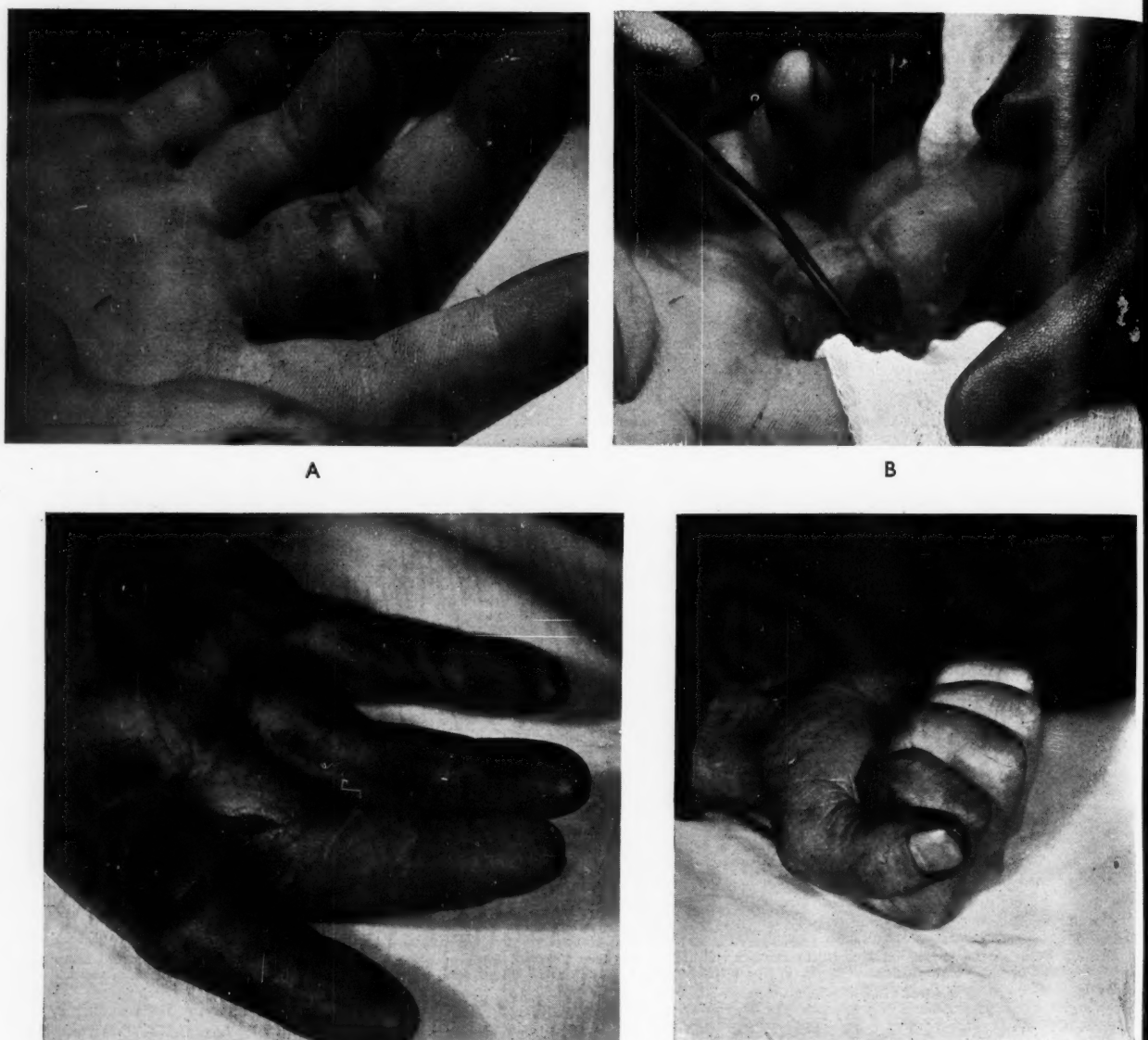

FIG. 512.—Case of suppurative tenosynovitis of the middle finger. A, Shows localization over the palmar aspect of the proximal interphalangeal joint, following on conservative treatment. B, Shows the tendon exposed at operation. C, D, The same case 16 days after operation, when the patient was already back at work. Wound almost healed and function complete.

at the site of pus formation. Function, by this time, is steadily improving.

Up to this point, the line of treatment employed throughout the three years has been fairly constant. In the first two years, when localization and pus formation had occurred, then surgery was invoked, and the abscess opened by the method to be described below, and which in a word could be described as 'saucerization'. *Figs.* 510–512 are illustrative of this method. Harrison, Topley, and Lennard-Jones (1949) have described a similar direct approach in their method of minimal incision.

dressing routine, and without anæsthesia of any kind.

Such collections are in most instances the superficial part of a collar-stud abscess, and, when the neck of the stud is inspected, a slough is often seen occupying the deeper compartment. Frequently this slough can be picked out, leaving a clean granulating cavity in the depths. This latter event may follow only after a day or two. Occasionally localization occurs quickly, and at some depth in the tissues, and in such cases incision has been resorted to, as it was felt that spontaneous eruption would take some time. The

results obtained in the two periods are compared in *Tables II* and *III*.

In the earlier period, the procedure adopted when complete resolution with pus formation had occurred was the following : The abscess was opened under general anæsthesia, and without a tourniquet. The author cannot agree with Pilcher and others (1948) in their advocacy of the use of local anæsthesia and a tourniquet in dealing with infections of the finger.

Table II.—Pulp Infections

This shows the results achieved in the treatment of pulp infections in the two periods under consideration, and gives the percentage subjected to definitive operative treatment.

Treatment Applied	No. of Cases	No. of Cases treated without Operation	Results		
			Loss of Terminal Phalanx	Stiff Distal Joint	Complete Recovery
Rest and heat. Parenteral penicillin and surgical incision immediately upon localization	431	101 (23 per cent)	8	4	419
Rest and heat. Parenteral penicillin with delayed minimal surgical interference	135	91 (68 per cent)	0	2	133

Such a method entails a varying degree of ischæmia in the finger, and this is basically unsound in the management of pyogenic infection. The method, applied alike to pulp and flexor cellulitis cases, was to open the abscess directly over its summit, and to use scissors. One blade of the scissors entering the cavity acts as a guide to depth, while the roof is cut away. All necrotic tissue was then wiped out of the cavity, and the true depth of the lesion revealed. In the finger these depths have been mentioned under the heading of pathology, but can be summarized again :—

1. The entire infection may be superficial to the fibrous tendon tunnel.

2. The space between the fibrous tunnel and the sheath may be the limit.

3. The lumen of the synovial sheath itself may be infected. *Figs.* 511, 512 illustrate cases of this depth.

4. The flexor tendons may show grey sloughs on their surfaces. These should be cut away, provided this can readily be done without materially damaging the tendon. The tendon of the flexor profundus is most frequently involved in this way.

After removing all sloughs, a non-adherent protective dressing was applied. Flavine emulsion has been used most frequently for this first dressing, and was left undisturbed for three days. No drainage tubes were ever used.

When this first dressing was removed, and, provided the timing of the incision had been good, the wound was found to be lined with healthy granulations, the surrounding œdema had subsided, and the patient was both willing and able to move the finger. If the tendon had been exposed at operation, it would now be found to be covered with granulations. Movements were now encouraged in all cases, whatever the depth of the infection. These movements must be purposeful, and must include flexion at both interphalangeal, as well as at the metacarpophalangeal, joints. The interossei must be exercised by abduction and adduction movements of the fingers. It is of supreme importance that these exercises be supervised at frequent intervals by the surgeon in charge of the case. He should see the more severe hand lesions at daily intervals, if possible, even although dressings may well be less frequent. In the later period, when spontaneous eruption has been allowed to occur, or where drainage has been established by snipping the purulent blister, active movements along the lines already described have been encouraged from the moment there is clinical evidence of complete localization and cessation of activity. This point is often reached before the pus is evacuated. The treatment is then similar in every way to that which has been described for the 'incision' cases.

Table III.—Flexor Cellulitis (Excluding Tendon-sheaths)

This gives the results achieved in the treatment of superficial infections of the proximal compartments of the finger in the two periods under consideration. Percentages of cases operated on are noted.

Treatment Applied	No. of Cases	No. of Cases treated without Operation	Results		
			Loss of Part or Whole of Finger	Limitation of Movement	Complete Recovery
Rest and heat. Parenteral penicillin and surgical incision immediately upon localization	228	77 (34 per cent)	0	4	224
Rest and heat. Parenteral penicillin with delayed minimal surgical interference	84	56 (67 per cent)	0	2	82

Dressings.—Apart from the fact that a dressing should always be regarded rather as a passive protective agent, and not as an active one, there are two points which seem to the author to be of first importance. No wet dressings or baths should be used in any hand infection. The dressings should be comfortable and adequate. The value of local applications of penicillin, and more recently of streptomycin, has been stressed by various authors (Curr, 1945; Watson, Griffiths, and Plewes, 1949). The writer has the clinical impression, without having made any extended or controlled trial, that these local applications are of secondary importance compared with the use of parenteral penicillin and delayed surgical interference. A sling should always be used until swelling has subsided and function is well established.

Healing.—Wounds on the flexor aspects of the fingers and hand, contrary to popular belief, heal rapidly and the scars are pliable and non-tender. Very few have shown any tendency to thickening and contracture. The important point is to gain quick healing with little or no discharge after the initial drainage operation, and this can best be achieved by awaiting adequate localization. To discourage movement in finger and deep palmar infections, once activity of the infection has subsided, is a mistake even when it has the laudable objective of achieving quicker healing. Function in the hand is the supreme consideration. The healing times for pulp infections and for cases of flexor cellulitis (excluding tendon-sheath infections) are shown in *Table IV*. Healing time, as here denoted, is the time taken for the wound to heal completely. The patients are then all fit for work, and the majority have returned to work, if they have been off at all, long before final complete healing has occurred. It is of interest to note that the healing time is not in fact extended by allowing spontaneous, or near spontaneous, eruption of the pus, and there is no question but that the patient has in this event a comfortable wound. In web infections, a group not specially discussed here, the method of spontaneous eruption has been very impressive. The writer's experience with web infections has been that, although splitting the web gives first-class drainage followed by rapid cessation of discharge, the wound often takes a considerable time to heal. Healing of the small natural opening, on the other hand, has been very rapid.

Table IV.—HEALING TIMES

TREATMENT APPLIED	AVERAGE HEALING OR ATTENDANCE TIME	
	Pulp Infections	Flexor Cellulitis (Excluding Tendon-sheaths)
Rest and heat, parenteral penicillin, and surgical incision immediately upon localization	17 days	15 days
Rest and heat, parenteral penicillin, with delayed minimal surgical interference	13 days Cases incised 16 days „ 'snipped' 13 „ No wound 6 „	12 days Cases incised 17 days „ 'snipped' 11 „ No wound 6 „

RESULTS

The results achieved are set out in tabular form. *Tables II* and *III* show the results for pulp infections and for cases of flexor cellulitis, excluding tendon infections. In each case the results in the two periods are compared. The first period, in which surgical incision under anæsthesia was most frequently used, extended from March, 1947, to September, 1948. The second period is from April to September, 1949. The period between September, 1948, and April, 1949, has been omitted, owing to the fact that it was a transitional period in regard to the timing of surgical attack. It must be emphasized, however, that the essential principles of treatment remain the same in both periods. That collections of pus in the pulp and in the soft tissues of the fingers (excluding tendon-sheath infections) can be allowed to erupt spontaneously, or with minimal aid, is not detrimental either to healing time or to ultimate function, appears to be a justifiable conclusion. This is contrary to the belief of Harrison and others (1949), who presented evidence demonstrating that pulp infections of a certain degree of severity, as judged by increase in volume of the pulp, were harmed by delayed surgery.

Cases of tendon-sheath infection, and with them are included infections of bone or joint where such infections complicated that of the tendon-sheath, are considered rather differently. The conservative line of treatment was applied to the cases of suppurative tenosynovitis, because the author had had uniformly bad results in his own practice with early surgery—results comparable to those achieved by surgeons who have admitted that a high proportion of fingers had to be amputated. Other factors that helped to point the way to conservative treatment were the availability of penicillin and the opportunity to see these cases as out-patients, and therefore frequently in an early stage of infection. Finally, the use of conservative treatment in pulp infections had proved profitable.

In these results, no case has been included in which the tendon-sheath has not been proved at operation, or on spontaneous rupture, to be the site of infection. Cases have occurred which clinically have been diagnosed as tendon-sheath infections, but which have cleared up without incision and without spontaneous discharge of pus. These have not been included in the results. In recent months, with the increasing tendency to allow spontaneous discharge, the number of cases definitely diagnosed as tendon-sheath infections has fallen, since visual, as compared with clinical, proof of infection of the sheath has not been so readily obtained.

In all three years, penicillin was used freely. At the beginning of 1947 early surgery, based on the

Kanavel principles, was employed, but, as the year advanced, the tendency to delay surgery became more and more frequent, and by 1948 what might be called the conservative treatment had been adopted. Between 1948 and 1949 there is no essential difference in the method of treatment, except that surgery was delayed even longer in 1949. The striking feature of *Table V* is brought out when the results obtained in 1947 are compared with those obtained in the two subsequent years. Of 12 cases seen in 1947, only 2 fingers (17 per cent) recovered complete function, whereas, in the two subsequent years, over 70 per cent of the fingers recovered function. The healing time was also greatly reduced.

Table V.—TENDON-SHEATH INFECTIONS
(*Including Infection of Bone and Joint where this followed Sheath Infection*)

In the case of tendon-sheath infections, the cases are divided into three groups. All cases were treated with parenteral penicillin. In 1947 the cases were subjected to early surgical incision along the lines of the teaching of Kanavel. Those in the subsequent two years were also treated with parenteral penicillin, but with delayed surgical interference. In 1949 the objective was spontaneous discharge.

Treatment Applied	Year	No. of Cases	No 'set' Operation	Results				Average Attendance Time in Days
				Hand Function	Finger Function	Movement	Loss of Tissue	
Parenteral penicillin with early surgical interference	1947	12	None	Good 6 Fair 3 Poor 3	Complete 2	Both i.p. joints stiff 5 Two fingers stiff 1	Distal phalanx 4	50
Rest and heat. Parenteral penicillin with 'saucerization' immediately abscess has formed	1948	34	None	Good 30 Fair 4	Complete 25	Both i.p. joints stiff 4 Terminal joint stiff 3	Whole finger 2	30
Rest and heat, parenteral penicillin, and delayed minimal surgical interference	1949	18	3*	Good 17 Fair 1	Complete 13	Both i.p. joints stiff 0 Terminal joint— Fixed 1 ¼ Normal range 2 ½ Normal range 2	None	28

i.p.—Inter-phalangeal.
*—Tendon exposed on spontaneous discharge of abscess.

Many will recall that in former days the infection of the tendon-sheath in the finger, and the operation carried out upon it, was only the prelude to a spreading suppurative lesion in the palm and forearm, and to a series of operations. It is noteworthy that in this series only one such case occurred, and that in 1947.

SUMMARY

1. The material on which this paper is based is a large series of cases (over 2000 hand infections) seen and treated personally during the past three years. Only 4 of these patients were in-patients at any time during their treatment.

2. The pathology of finger infections is discussed, and the importance of inflammatory, as opposed to anatomical, barriers is stressed.

3. The principles guiding treatment, as popularized by Kanavel, are criticized, especially that of early surgical intervention.

4. The principle of conservative treatment, with later surgical intervention, is substituted. The importance of this lies in the fact that the general practitioner can adopt this method, and only rarely will he need the help of the surgeon. While the elaborate procedure described by Loudon and his co-workers (1948) may be admirable under certain circumstances, it is not practical when dealing with numbers such as are considered in this paper, and in the author's opinion not justifiable or necessary. The interference recommended is similar to the minimal incision of Harrison and others (1949), but is longer delayed, less elaborate, and, in the vast majority of cases, does not require anæsthesia of any kind.

5. This method has been applied to all finger infections, including tendon-sheath infections.

6. Results are tabulated and healing times given.

I should like to offer my thanks to Sister Morrison and an ever-changing nursing staff in the Casualty Department of the Victoria Infirmary for their loyal co-operation and technical skill; to Professor Illingworth for his helpful advice and criticism; to many of my senior colleagues for their encouragement in this work; and to the Superintendent, Victoria Infirmary, for permission to publish the results. I should also like to thank Mr. H. Gray, Clinical Photographer, Victoria Infirmary, for the photographs.

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RUPTURES OF THE ROTATOR CUFF

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Ruptures of the intrinsic tendons of the glenohumeral joint have been recognized since the work of the early great anatomists, but the clinical application of this knowledge has been a fairly recent development. The earliest illustration of such lesions that I have found was in the Thesis of Monro presented in Paris, 1788, entitled "All the Bursæ Mucosæ of the Human Body". (*Fig.* 513.)

The late Dr. Codman must receive the credit for describing the clinical picture of these injuries, and

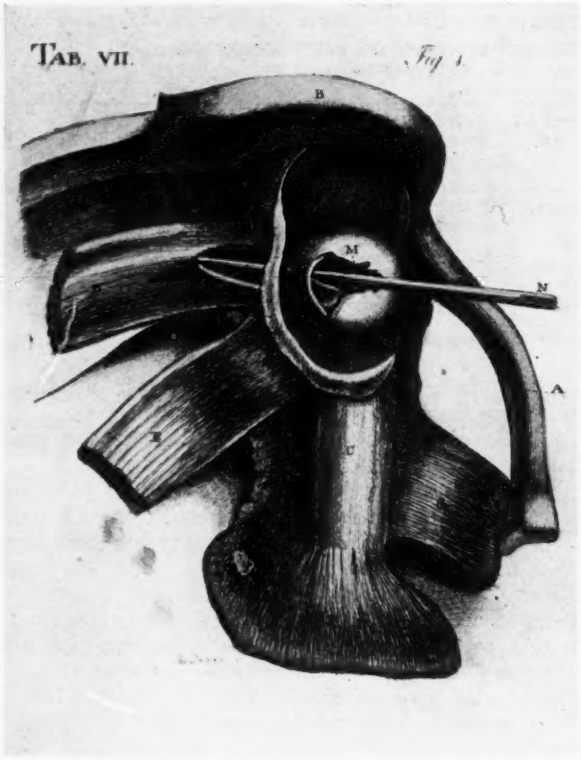


Fig. 513.—Monro's illustration, 1788. A, Clavicle; B, Acromion; C, Humerus; D, Infraspinatus; E, Teres minor; M, Ruptured cuff with probe in situ.

there is little that can be added to the accurate observations recorded in his scientific paper and in his masterpiece, *The Shoulder*. It must be noted, however, that Codman's experience was limited to 38 cases collected over an equal number of years and that in the year of his death, 1938, he operated on his one and only case of complete rupture explored within a week of the injury.

"I wish you could have been here to see one of my recent cases—the first one that I have ever been able to see at a really early stage. He came to me the day after the injury. The tear was found to be quite fresh, no falciformed edges were found. The individual ends of the fibres of the tendon could be seen. The whole rent was exactly the extent shown in the frontispiece of my book but, as the case was fresh, a stub of tendon containing the palisades was still present on the tuberosity at the place where, in the frontispiece picture, we find the 'red, granulation-like irregular surface'. In this patient, when, after a long time, the stub of tendon had been worn away from the tuberosity, the appearance would have become exactly as is shown in the picture. Since I obtained the case so early, I could approximate the retracted tendons to the stub almost perfectly, without much tension.

"It is interesting that up to this time, after having been talking about this condition for thirty-odd years, this is the first fresh case I have ever seen."*

The remainder of his cases were chronic and the operative repair was difficult and often unsatisfactory.

Further, Codman focused the attention on the supraspinatus, whereas subsequent studies suggest that the subscapularis tendon is frequently involved and unless carefully examined at operation a negative exploration will be recorded. The operative findings may disclose any extent of rupture, whether of the supraspinatus or subscapularis alone or in association with the other tendons. As the short rotators form a structural and functional unit with the capsule at the 'critical zone' where ruptures occur, it is considered that the term 'rotator cuff' will be more satisfactory from a clinical point of view and that the clinical diagnosis, 'rupture of the rotator cuff' should be made in place of 'rupture of the supraspinatus tendon'.

One additional point merits mention, and this refers to the concomitant injuries to the long tendon of the biceps. It is only comparatively recently that the complete dislocation or simultaneous rupture of this tendon has been noted in association with cuff ruptures and the appropriate repair instituted.

ANATOMICAL CONSIDERATIONS

Components of the Rotator Cuff.—There are four components of the rotator cuff: the supraspinatus, infraspinatus, and teres minor inserted into the greater tuberosity; and the subscapularis, which is attached to the lesser tuberosity. These tendons also fuse over a variable area with the joint capsule. This fusion is more extensive on the superior and anterior than on the inferior and posterior aspects of the joint.

Teres Minor (*Fig.* 514).—The teres minor arises from the axillary border of the scapula and is inserted into the inferior facet on the greater tuberosity. Muscular fibres also extend to insert on the humerus below the tendinous insertion.

Nerve-supply: This muscle is morphologically a part of the deltoid, which accounts for its innervation by a separate branch of the axillary nerve (C.5, 6, 7) (*see Fig.* 518).

* Personal communication.

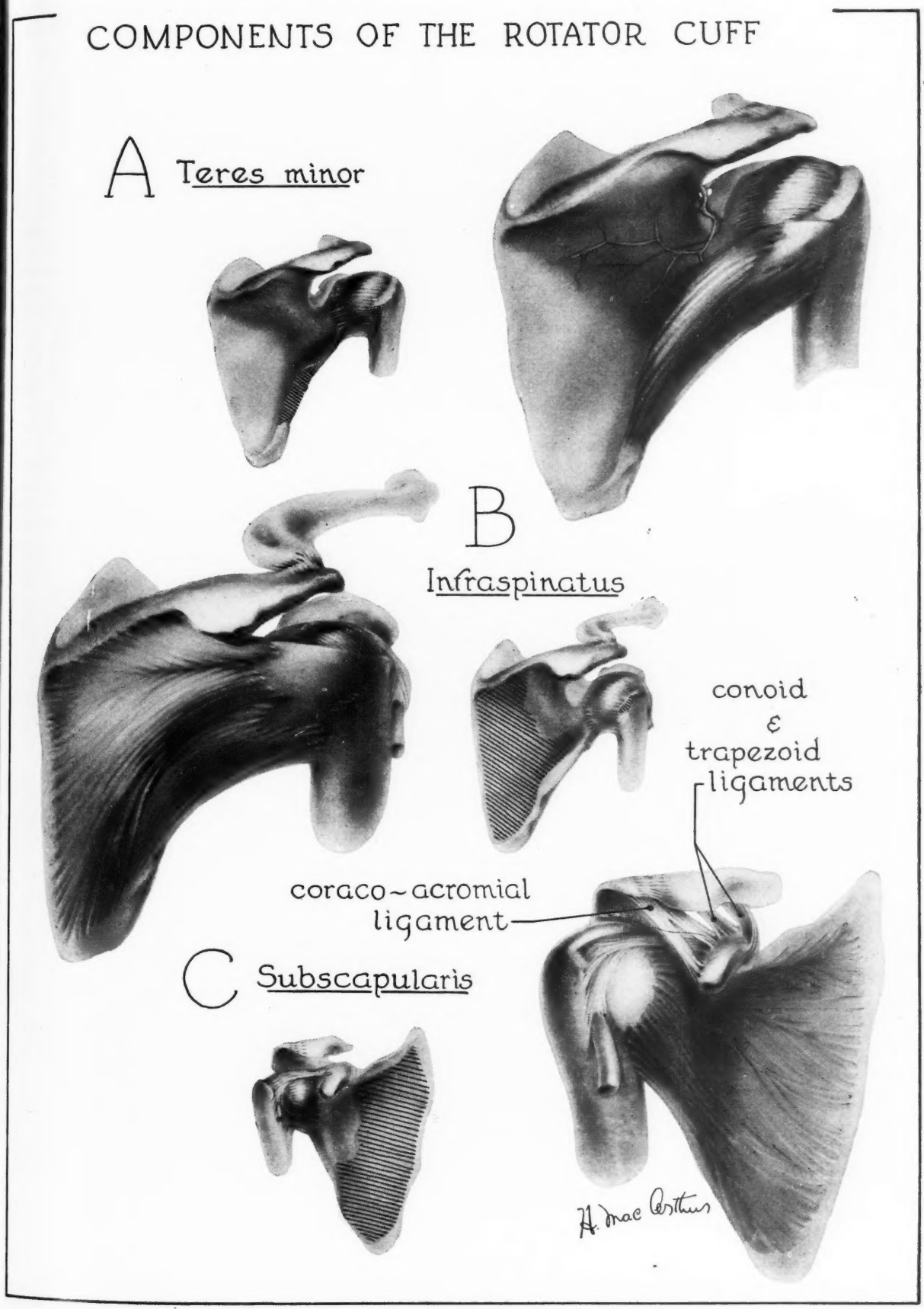

COMPONENTS OF THE ROTATOR CUFF
A Teres minor
B
Infraspinatus
conoid
&
trapezoid
ligaments
coraco-acromial
ligament
C Subscapularis
H. Mac Arthur

FIG. 514.

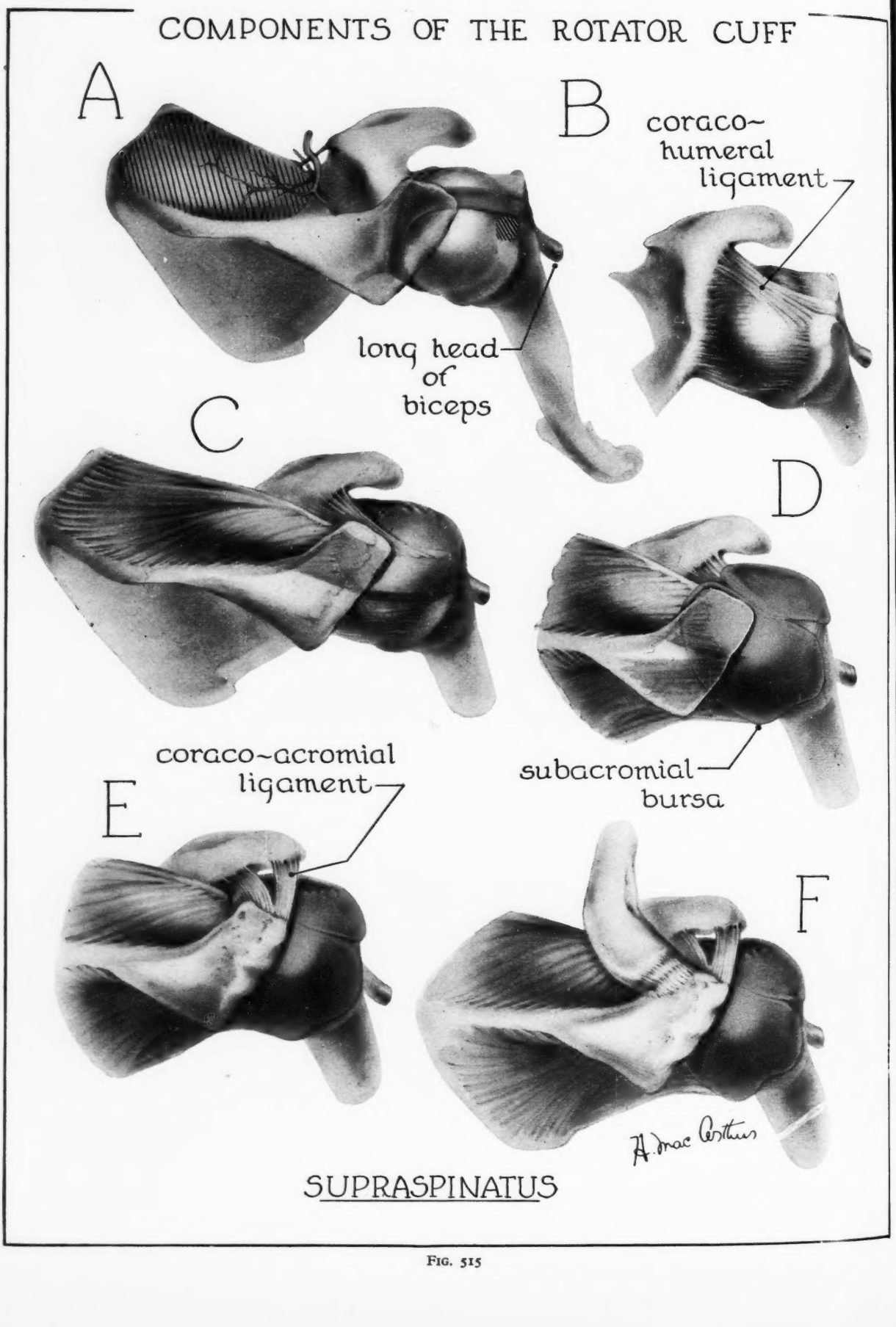

COMPONENTS OF THE ROTATOR CUFF
A
B
coraco-
humeral
ligament
long head
of
biceps
C
D
subacromial
bursa
coraco-acromial
ligament
E
F
A. Mac Arthur
SUPRASPINATUS

FIG. 515

Infraspinatus (*Fig.* 514).—The infraspinatus originates from the infraspinous fossa and inserts into the capsule and greater tuberosity. It forms a structural and functional unit with the teres minor. The evolution of the orthograde posture and the development of the abduction mechanism of the shoulder-girdle are associated with a great enlargement of the infraspinatus muscle in the anthropoids and man.

Nerve-supply: Branches of the suprascapular nerve (C.4, 5, 6).

Subscapularis (*Fig.* 514).—The subscapularis arises from the subscapular fossa and its tendon extends to its insertion on the lesser tuberosity. Muscular fibres continue to attach to the humerus below the tendinous insertion. Fusion with the capsule occurs lateral to the glenoid rim. This fact has importance in the study of the post-traumatic anatomy of anterior dislocations of this joint. The subscapularis anteriorly balances in size and power the infraspinatus and teres minor posteriorly.

Nerve-supply: Branches of the subscapular nerves (C.5, 6, 7).

Supraspinatus (*Fig.* 515).—The supraspinatus extends from its origin in the supraspinous fossa to fuse with the capsule and insert onto the greater tuberosity posterior to the bicipital groove. Its anterior border is separated from the superior border of the subscapularis by capsular tissue largely composed of the variable coraco-humeral ligament. In the cleft between these two components of the cuff lies the intra-articular portion of the biceps, which passes in its synovial invagination from the supra-glenoid tubercle to enter the bicipital groove.

The tendon of the supraspinatus arises from the muscular belly beneath the acromion. The relative length of tendon to muscle is variable. The contiguity of the tendon to the coraco-acromial arch must be emphasized, and special attention must be drawn to the relation of this structure to the inferior aspect of the acromio-clavicular joint. Fatty areolar tissue, the subacromial and subcoracoid bursæ, separate the tendon from the coraco-acromial arch and deep aspect of the acromio-clavicular joint. These anatomical relationships are stressed because the author has correlated them with operative findings. An upward thrust from a fall on the elbow may impact the supraspinatus tendon against the inferior surface of the acromion. The resultant injury varies from a simple contusion to complete rupture of the tendon. Further, degenerative arthritis of the acromio-clavicular joint causes inferior lipping of the clavicle and prominence of the inferior capsule, which frequently set up an irritative subacromial bursitis. Communication between the joint and the bursa may develop. The symptoms and signs are those of a derangement of the gleno- or supero-humeral joint.

Although the subacromial and subcoracoid bursæ are frequently continuous, they are shown as separate bursæ in this series of illustrations. This has been done in order that the surgeon may remember to explore more anteriorly when he opens the subacromial bursa and finds the exposed cuff normal and a bursal reflection present at the anterior border of the supraspinatus tendon. He will then open the separate subcoracoid bursa and find the ruptured subscapularis tendon when present.

Nerve-supply: Suprascapular nerve (C.4, 5).

Components of the Gleno- and Supero-humeral Joints (*Figs.* 516, 517).—The components of the rotator cuff are four of the many components of the scapulo-humeral or shoulder-joint. It has been found necessary for detailed clinical study to divide this articulation into the following units of movement:—

a. Gleno-humeral joint;
b. Supero-humeral joint;
c. Bicipital tendon-sheath mechanism.

The gleno-humeral joint is the term used to define the articulation of the humeral head with the glenoid fossa. The *supero-humeral joint* is formed between the coraco-acromial arch and the humeral head covered by the rotator cuff. The subacromial and subcoracoid bursæ provide the gliding surfaces.

The scapula, humerus, and clavicle are the bones concerned. The relatively large articular surface of the humeral head to the small, shallow, pyriform glenoid fossa is a point of great importance. The capsule is thin and lax, but the slack is taken up in the living subject by the tonic activity of the cuff muscles. The cuff is absent inferiorly where the capsule is most lax, to enable the downward passage of the head as elevation of the arm progresses.

A study of the coraco-acromial arch from below (*Fig.* 516) demonstrates the greater space in the posterior area into which the head rotates on abduction of the arm above the horizontal plane. This view again illustrates the relation of the inferior aspect of the acromio-clavicular to the supero-humeral joint. It will be seen also how well the head of the humerus is protected by these bony and ligamentous structures from damage by external violence from above.

The extent of the subacromial and subcoracoid bursæ is shown as the author has found them at operation. Considerable variability naturally exists. The floor of the subacromial bursa is attached firmly over the greater tuberosity, and the roof to the under-surface of the acromion and coraco-acromial ligament. The fixation is more extensive over the cuff with advancing years. Great differences exist in the thickness of the bursal wall and in the presence of adhesions in cases of degenerative periarthritis. The subcoracoid bursa extends well up to the base of the coracoid and down under the upper part of the coracobrachialis and short head of biceps. It is well seen when the tip of the coracoid is detached and turned downwards in the anterior approach to the joint.

Axillary Relations of the Cuff and Gleno-humeral Joint (*Figs.* 518, 519).—Our anatomical study of the cuff would not be complete unless we considered its axillary relations. It is extraordinary how static the modern approach to anatomy appears to be and how difficult it is to visualize anatomical relations when the positions are changed from the 'anatomical position'. This is certainly true for the visualization of the relative position of structures when the arm is in varying degrees of elevation. The author is indebted to Dr. Sterling Bunnell for stimulating him to study the gleno-humeral joint from the axilla.

Figs. 518, 519 build up the anatomical relations in the position for the surgical approach through the axilla. The inferior muscular borders of the teres

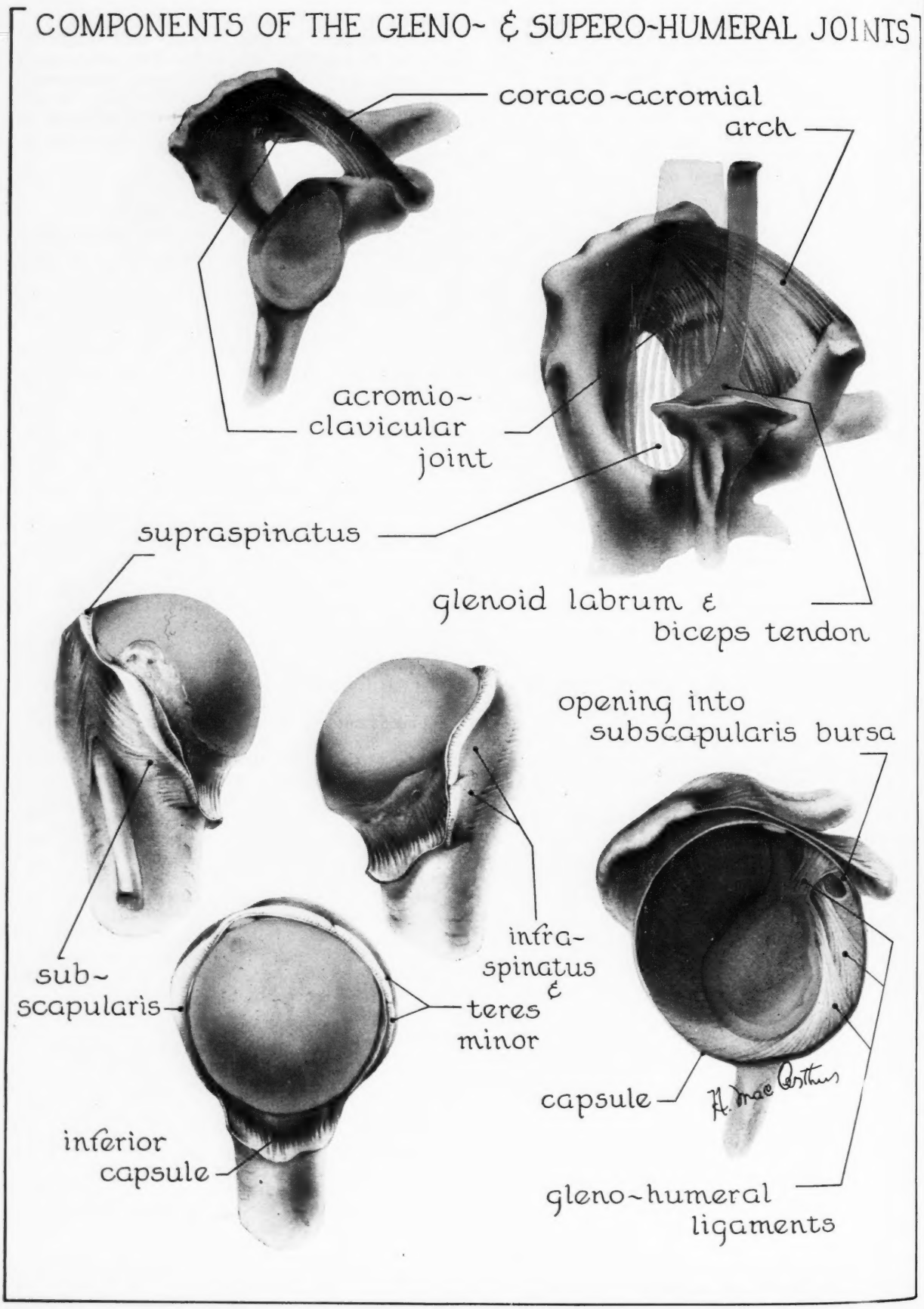

COMPONENTS OF THE GLENO~ & SUPERO-HUMERAL JOINTS
coraco~acromial
arch
acromio~
clavicular
joint
supraspinatus
glenoid labrum &
biceps tendon
opening into
subscapularis bursa
infra~
spinatus
&
teres
minor
sub~
scapularis
capsule
inferior
capsule
gleno~humeral
ligaments

FIG. 516.

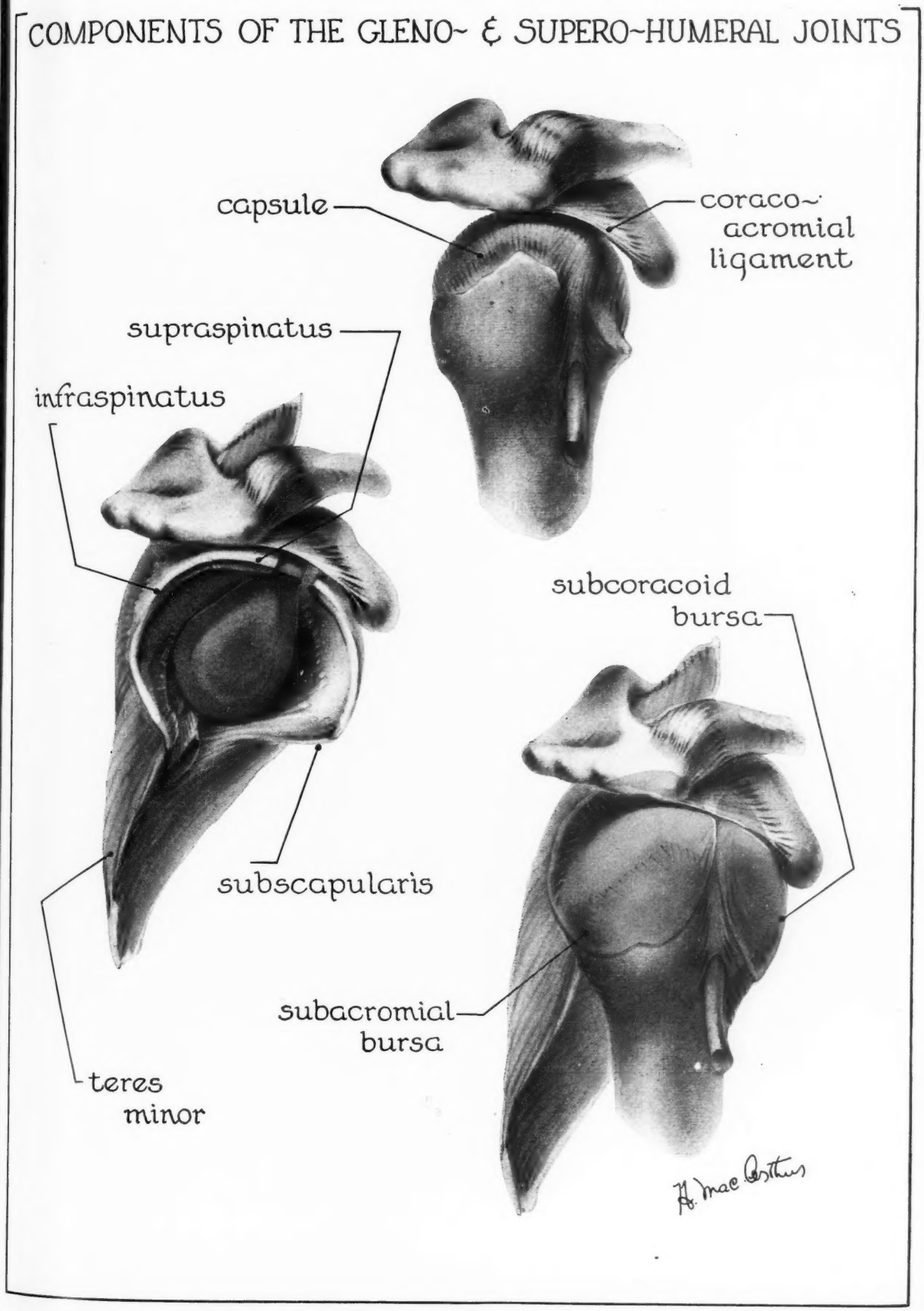

COMPONENTS OF THE GLENO~ & SUPERO~HUMERAL JOINTS
capsule
coraco~
acromial
ligament
supraspinatus
infraspinatus
subcoracoid
bursa
subscapularis
subacromial
bursa
teres
minor
H. MacArthur

FIG. 517.

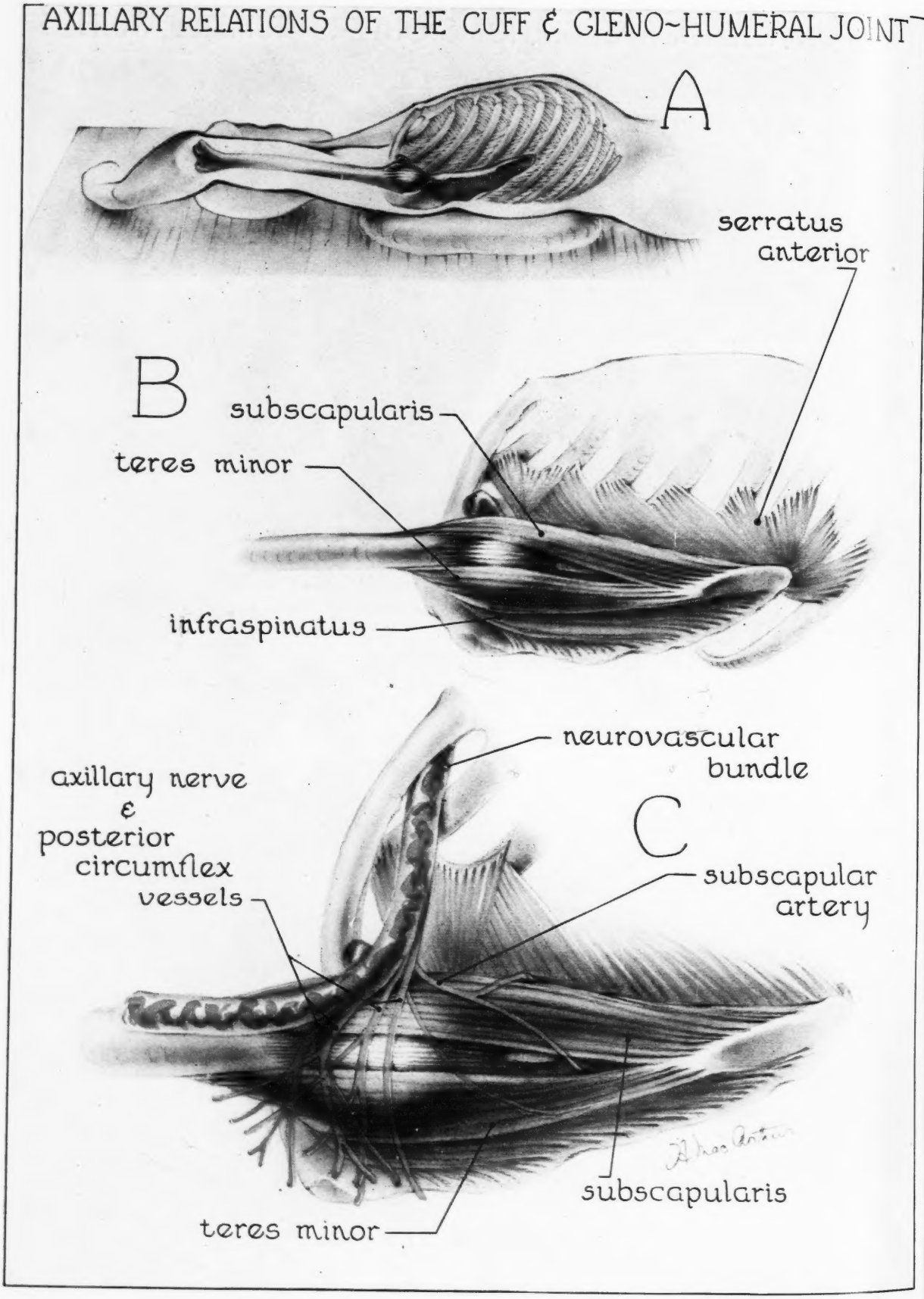

AXILLARY RELATIONS OF THE CUFF & GLENO-HUMERAL JOINT
A
serratus anterior
B
subscapularis
teres minor
infraspinatus
neurovascular bundle
axillary nerve & posterior circumflex vessels
C
subscapular artery
subscapularis
teres minor

FIG. 518.

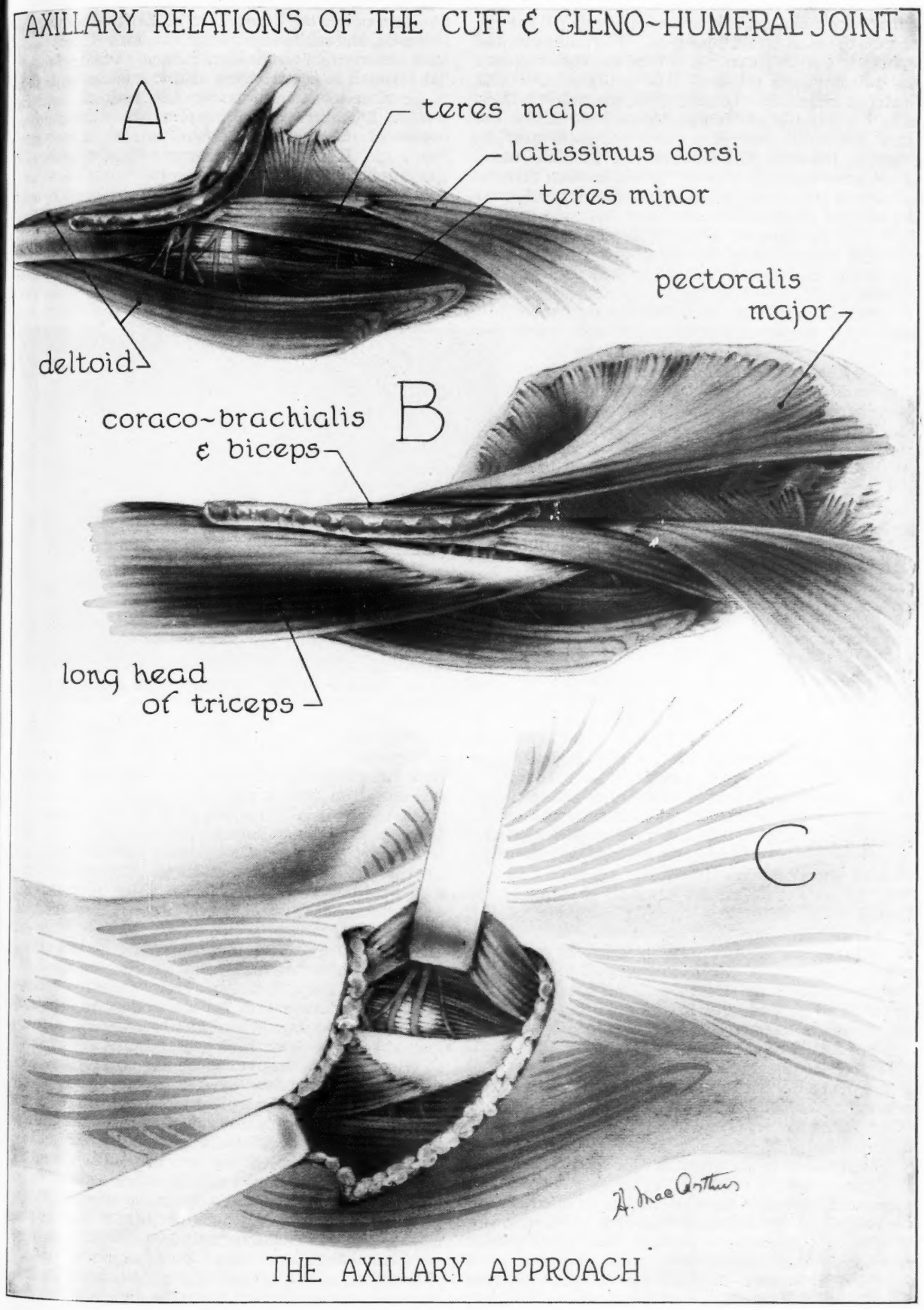

AXILLARY RELATIONS OF THE CUFF & GLENO-HUMERAL JOINT
A
teres major
latissimus dorsi
teres minor
pectoralis major
deltoid
B
coraco-brachialis & biceps
long head of triceps
C
A. MacArthur
THE AXILLARY APPROACH

FIG. 519.

minor and subscapularis are seen passing from the scapula to insert on the humerus. The neurovascular bundle is seen in its course around the coracoid onto the subscapularis muscle. The axillary nerve and posterior circumflex vessels cross the subscapularis onto the capsule and thence posteriorly across the teres minor, to enter the deltoid muscle near its posterior border. The separate branch of the nerve to the teres minor is shown. It will be seen that the nerve and vessels run across the axillary capsule near the neck of the humerus and away from the inferior aspect of the glenoid rim. This course, together with the protection to the nerve given by the subscapularis, explains the infrequency of paralysis and rupture of the nerve in antero-inferior dislocations.

Operations on the shoulder through the axilla have taught one other point, and that is the great protective action of the long head of the triceps to the inferior aspect of the joint. It is readily seen that dislocations must occur either anterior or posterior to this structure, which is tautly stretched over the prominent capsule and head of the humerus when the arm is fully abducted. Antero-inferior dislocations thus pass over the glenoid rim anterior to this tendon, tearing the capsule and part of the subscapularis.

The study of the post-traumatic anatomy found through the axillary approach should provide further information in the future on the lesions of the capsule and subscapularis in dislocations of the shoulder.

FUNCTION OF THE ROTATOR CUFF

The rotator cuff is the fine adjustment in the mechanism of the gleno-humeral joint. One of its chief functions is to maintain the fulcrum of the humeral head on the glenoid fossa in the varying positions of the humerus in relation to the scapula. Although the cuff acts as a unit and is only one of several groups of muscles acting simultaneously in any movement of the arm-trunk mechanism, some idea of the sum total of its action can be gained by determining the isolated actions of its various components. In this connexion there is little to be added to the original observations of Duchenne.

Teres Minor, Infraspinatus, and Subscapularis.—The infraspinatus and teres minor are external rotators of the humerus and the range of this movement is 45° from a position of mid-rotation or 90° from a position of full internal rotation. The subscapularis counterbalances this action on the anterior aspect of the joint.

It will be noted that the rotatory activity of these components of the cuff is essential to the smooth rotation of the hand necessary in writing, sewing, and other functions requiring the passage of the hand from left to right.

As the arm is abducted and adducted these two groups of muscles assist in the smooth descent and ascent of the head in the glenoid, and in this function are helped by the supraspinatus and long tendon of the biceps superiorly and the long head of the triceps and coracobrachialis inferiorly and anteriorly.

Supraspinatus.—The supraspinatus function has always been a subject of controversy. Isolated faradism causes the humerus to be elevated outwards, forwards, and with some medial rotation. Cases have been reported where isolated paralysis of the deltoid has resulted in hypertrophy of this muscle, with full range of abduction movements but with diminished power. Duchenne noted that faradism of the deltoid resulted in a subluxation downward of the humeral head, and it is this movement which the supraspinatus activity obviates.

Electromyographic studies of cases with complete ruptures of this tendon proven at operations have suggested to Dr. Jasper and the author that normally the supraspinatus alone initiates the first 20–30° of abduction of the arm. At this point the middle segment of the deltoid associates itself with the supraspinatus. If the slightest resistance is offered to initiation of abduction, both muscles are activated from the beginning. In case of complete rupture of this tendon of sufficient extent to remove the stretch-reflex mechanism the supraspinatus will usually be found electrically quiescent, and this may prove in time to be of diagnostic significance. Difficulty in interpretation will be caused if electrical activity persists because of the attachment of the torn cuff to unruptured tendon or if spasm of the affected muscle belly is present.

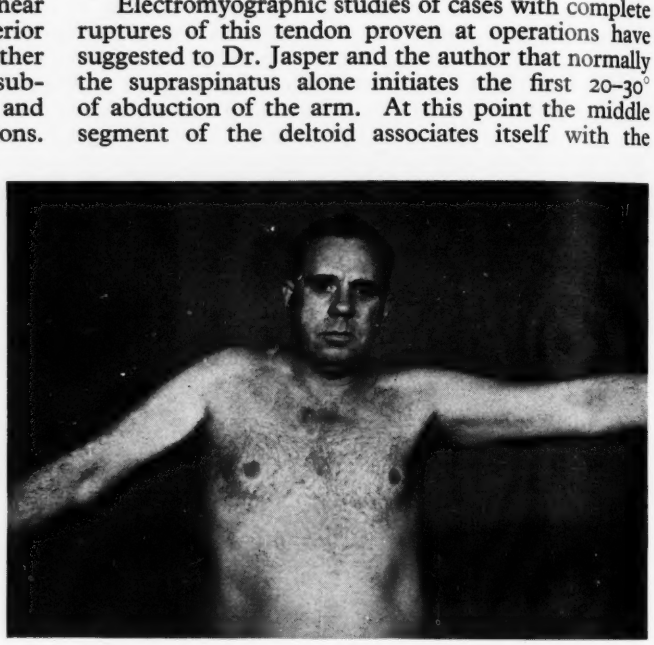


FIG. 520.—Limitation of abduction. Rupture of supra- and infra-spinati two months after accident. Lesion illustrated in *Fig.* 528.

When the supraspinatus is acutely ruptured abduction in the normal manner is lost, because the deltoid draws the humerus directly upwards against the coraco-acromial arch and the abduction is gained by scapular motion with a locked gleno- and supero-humeral mechanism (*Fig.* 520). If, however, local anæsthesia is infiltrated to remove the protective pain-reflex, full movement can be obtained, which proves that the supraspinatus is not essential to initiate abduction. If the power to maintain abduction at 90° is tested, it will be found to be greatly diminished in complete ruptures of the full extent of the supraspinatus insertion. This is because of the loss of the supraspinatus function in fixing the fulcrum of the humerus. Clinical use of this test in all degenerative and traumatic lesions of the tendon is of great diagnostic value. Naturally, more extensive and massive avulsions will demonstrate the loss of power more dramatically. In time the healing

process tends to restore some of this function, but loss of power can always be demonstrated.

Long Tendon of the Biceps.—The function of the long tendon of the biceps in its intra-articular portion must be mentioned in this connexion. It acts as a ligamentous band over the humeral head to depress it when a weight is taken in the hand for elevation through the combined flexor activity of the brachialis and biceps. This function is also part of that of the rotator cuff and the coraco-acromial arch, which take over when the biceps tendon is ruptured or removed.

Long Head of Triceps and Coracobrachialis.—Two other muscles assist the rotator cuff and long tendon of the biceps in maintaining the fulcrum in the gleno-humeral articulation. When the arm is being abducted from an elevated position by the powerful latissimus dorsi and lower fibres of the pectoralis major, the long head of the triceps and the coracobrachialis hold firm the fulcrum by their upward action on the humeral head preventing its downward subluxation.

The Relation of the Functions of the Cuff and the Gleno- and Supero-humeral Joints.—The smooth rotation of the humeral head, with its descent and ascent in the glenoid fossa, presupposes a normal arrangement in the subacromial and subcoracoid bursæ. Any interference with this rotatory motion by adhesion of the bursal surfaces, contractures of the rotator cuff muscles, or fixation in the bicipital tendon-sheath mechanism, automatically limits the elevation of the humerus on the scapula. Such changes are secondary to ruptures of the cuff as well as to other pathological processes in these structures, and they give the limitation of movements characteristic of these shoulder lesions.

RUPTURES OF THE ROTATOR CUFF

Definitions (*Fig.* 521).—Ruptures of the rotator cuff vary in their degree from the tear of a few fibres in the substance of the tendon or on the joint or bursal side, to tears involving the full thickness of the cuff. The term *complete ruptures* should be used for the tears involving the full thickness of the tendon and capsule, permitting a communication between the joint and the bursa when the bursal floor is also torn. A complete rupture may involve a varying extent of the cuff insertion—most commonly the supraspinatus or subscapularis tendons are singly disrupted, but any extent may be present up to complete separation of the whole cuff. These extensive lesions are called *massive avulsions*. The *partial ruptures* by definition would therefore be considered injuries of lesser degree. Ruptures, whether partial or complete, always occur at the 'critical area' near the insertion of the tendons into the bony tuberosities of the humerus. It is to be noted that these definitions are based more on anatomical than clinical findings, but with experience the two become as one.

Aetiology.—In considering the development of traumatic lesions of the rotator cuff and their sequelæ, the author has been interested to correlate the ruptures in this area with ruptures of the intervertebral disks and to recognize that we are analysing the early stages of traumatic and degenerative arthritis.

The predisposing factors are well understood. The age of the patient is of primary importance. It is almost impossible to rupture these tendons in a normal young adult, but from the fifth decade onward degenerative changes occur which increase with the years. In the earlier decades the cuff will avulse part or the whole of a bony tuberosity (*Fig.* 522). After the fifth decade, however, the lessened strength of the tendon, owing to the loss of its fibrillar structure and elastic fibres, permits rupture of the tendon substance. These degenerative changes are most marked at the critical area of the tendon near the tuberosity, where ruptures and calcified deposits occur. (*Figs.* 521, 523.)

This process of ageing may go on gradually through the years, and minor traumata may summate in the attritional wearing through of the supraspinatus tendon. With this there develops a communication between the joint and the subacromial bursa. There is an increased amount of joint fluid, which is pumped into the bursa on elevation of the arm. In this way nature arranges a fluid buffer between the humeral head and coraco-acromial arch, which replaces, in part, the function of the cuff lost by attrition or injury. The biceps tendon is exposed and the attritional process then occurs in this structure as it rubs between the humeral head and the coraco-acromial arch as well as glides in the roughening groove. In time, this tendon, too, frays through near its exit from the joint, giving a spontaneous rupture of the long tendon of the biceps. Sometimes the distal end becomes fixed in the bicipital groove and all that is noted is some flaccidity of the corresponding muscle belly. The intra-articular portion gradually disappears.

These changes in tendon structure result in loss of tensile strength as tested clinically, which is characteristic of the process of ageing. Further, as the stress and strain at the tendinous insertion lessen, the tuberosity undergoes recession by absorption so that when the cuff is finally worn through, the raised eminence is levelled to a smooth surface continuous with the articular cartilage. There is then, on elevation of the arm, no mechanical interference to the passage of the humeral head beneath the coraco-acromial arch. This is an excellent demonstration of Wolff's law and corresponds well with the absorption of the alveolus of the jaw as the teeth are lost, so well described by John Hunter. Furthermore, as the process takes place over a considerable period of time, the balance between the powerful muscles such as the deltoid, and the fine adjustment mechanism, represented by the rotator cuff muscles, is preserved, though with lessened strength. It is interesting that this natural adjustment appears to continue the evolutionary process which comparative anatomy reveals. As the animal scale is ascended, there is the great development of the acromion and a relative loss of development of the tuberosities with the achievement of the upright posture. This is especially noticeable with the evolution of the abduction mechanism.

During the years, while these changes are slowly progressing, the patient may be conscious of recurring pains and stiffness in the shoulders, most marked on overuse, and often with tenderness localized in the bicipital groove and with pains radiating down the

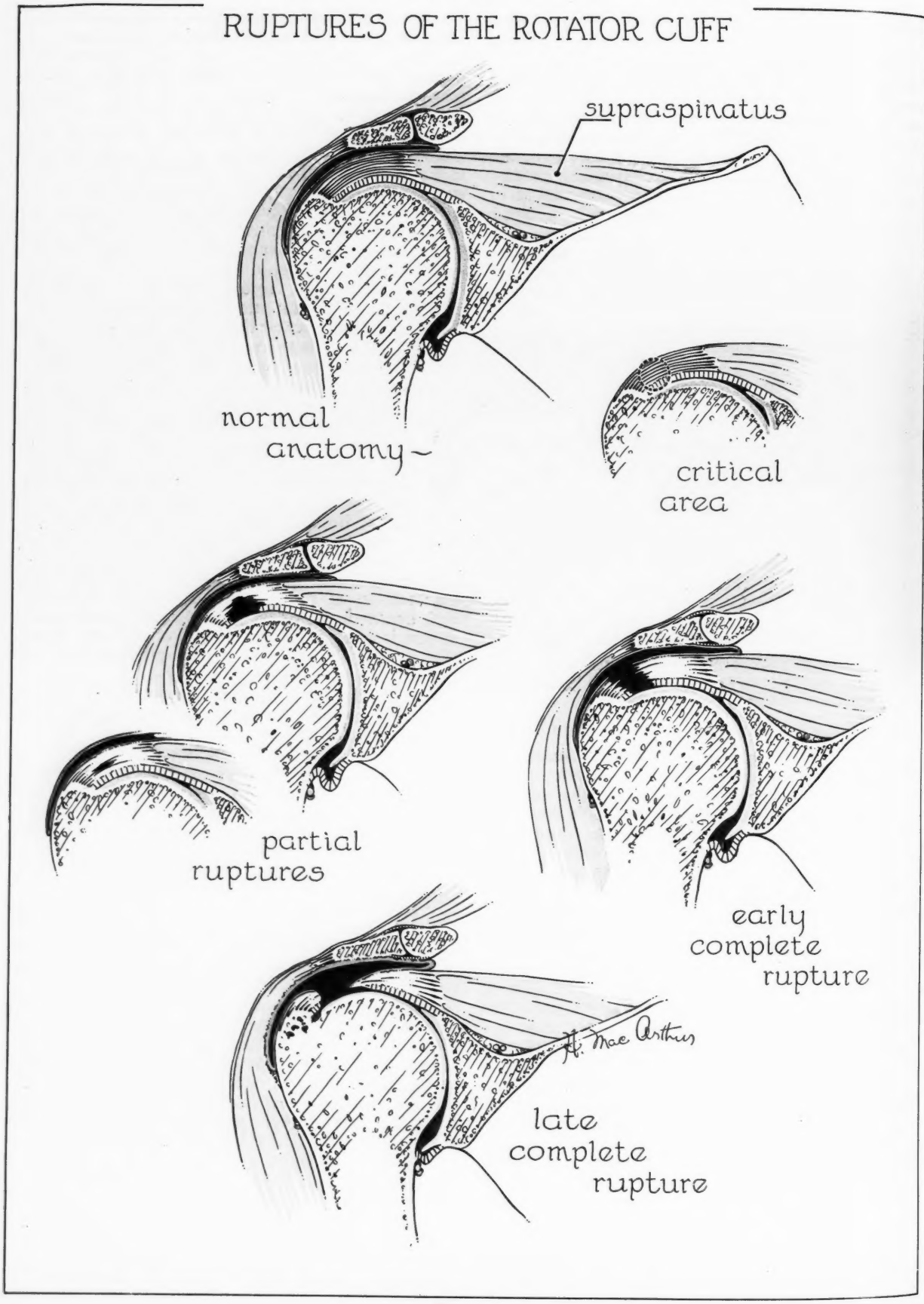
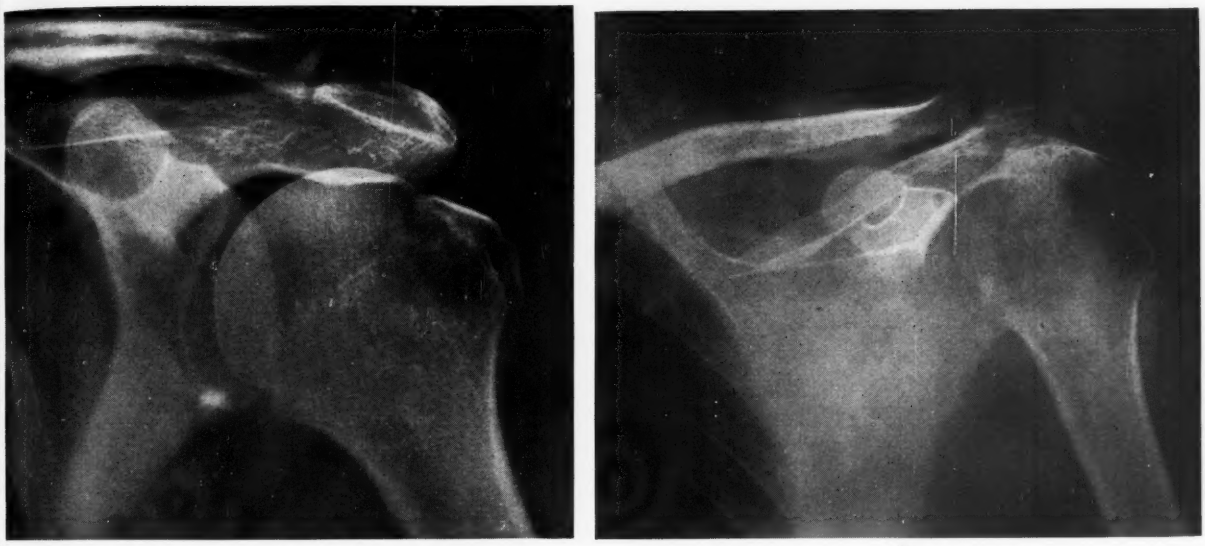

RUPTURES OF THE ROTATOR CUFF
supraspinatus
normal anatomy
critical area
partial ruptures
early complete rupture
late complete rupture
H. Mac Arthur

FIG. 521.

flexor surface of the arm to the elbow. This is the process of ageing in the shoulder and corresponds to the osteo-arthritis occurring in the weight-bearing joints of the lower limbs, e.g., hip and knee. The designation *degenerative periarthritis* can be appropriately applied to this process of ageing in the shoulder.

Excellent studies of degenerative periarthritis have been made and published by Codman, Akerson, Meyer, Skinner, Keyes, Wilson, and De Palma. It is found that approximately one in four subjects from the fifth decade onward show ruptures of the cuff in varying degrees and that the numbers increase as the older groups are investigated. Males are affected more often than females and the lesions are more frequent in the right than the left shoulder, since the majority of people are right-handed. There is a greater tendency to these changes in the labouring classes, where the stress and strain produce the lesions of wear and tear. Further, there appears to be a higher incidence in those working at occupations requiring exertion beyond that to which the individual is accustomed. Alcoholics and diabetics appear to be prone to these degenerative processes. Such investigations on the age changes in the shoulder should be correlated with those by Schmorl on the intervertebral disks and spine, and with those of Bauer and his co-workers on the corresponding changes in the knee-joint.

Degenerative periarthritis is, therefore, the principal factor predisposing to rupture of the rotator cuff, and the force required to disrupt the tendons will naturally vary with the stage of this deterioration. The labourer is the subject who chiefly visits the physician with the worn-out shoulder to which the insult of an acute injury has been superadded.



A B

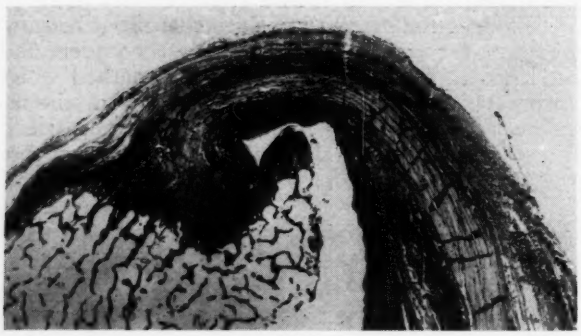
FIG. 522.—A, Radiograph showing avulsion of supraspinatus facet with healing three weeks after accident. B, Avulsion of greater tuberosity with marked displacement.

CLINICAL PICTURE

The Early Case.—The patient is typically a male labourer of more than 50 years, who, after a severe strain of the shoulder or a heavy fall, felt an acute pain and snap in the shoulder followed by inability to abduct his arm. The worker may carry on after the accident favouring the limb, but usually has to quit his work. The pain reaches great severity 10–12 hours later and thus a characteristic point in the history is the inability to sleep that night because of this severe pain. It must be clearly understood that the symptoms and signs are less marked when ruptures occur in senile cases with advanced degenerative periarthritis after a minor injury in comparison with the heavily muscled labourer after a severe injury. The patient almost invariably seeks medical advice within the first few days and it has been a further characteristic of the patient's story in late cases that the doctor arranged radiological examination, found no evidence of fracture or dislocation, and diagnosed a sprain of the shoulder which would clear up in a few days.

Local Examination.—Examination of the shoulder within the first few days is typical. The patient is asked to abduct the arm, which he does with considerable pain and with the use of the shrugging mechanism (*Fig.* 520). If the weight of the limb is taken, the arm can usually be elevated to the horizontal plane. At this point the patient is asked voluntarily to hold his arm in this position. Many patients can do this, but the slightest pressure in a downward direction by the examiner increases the pain and the arm is brought down with difficulty or falls to the side. More can be learned if this test is carried out in varying degrees of humeral rotation. This is the characteristic diminution in power to maintain abduction and is seen in its most typical form in extensive ruptures where the passively abducted arm falls to the side when the support is removed, i.e., the 'drop arm' sign for complete rupture of the rotator cuff. Judgement in evaluating this sign is important, and confusion occurs because of the individual variations in pain threshold. In some cases the mechanism to maintain abduction at a right angle by deltoid action is easily inhibited by

pain. It is when in doubt in this respect that the writer recommends the infiltration of the point of maximum tenderness with 10 c.c. 1 per cent procaine.



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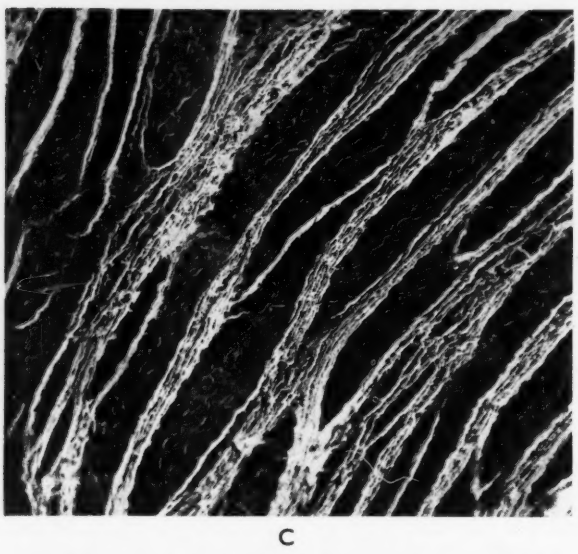

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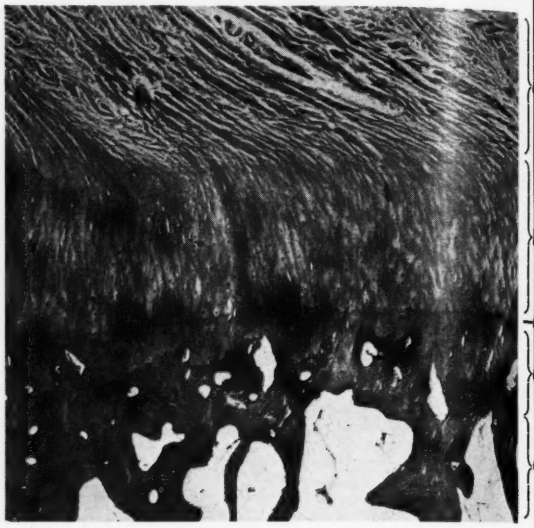

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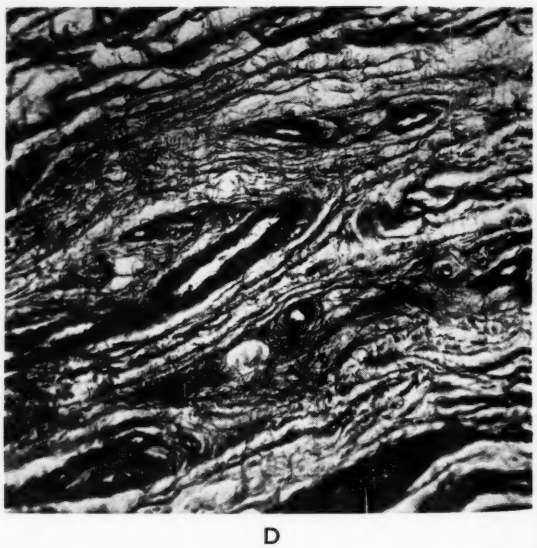

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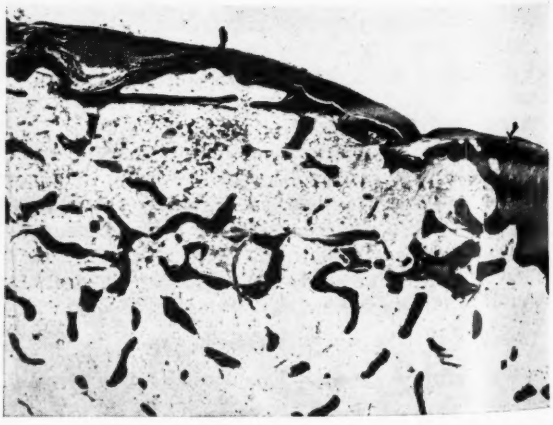


E

FIG. 523.—A, Photomicrograph at very low magnification of histological section of normal supraspinatus tendon and its insertion. The dark borders on the upper and lower surfaces of the tendon aponeuroses represent the base of the subacromial bursa and the capsule of the shoulder-joint, respectively. Only the pale central portion is true tendon. (Mallory's connective tissue stain.)

B, Photomicrograph of the normal insertion of the supraspinatus tendon from a male, aged 21, who died from shock shortly after sustaining extensive burns of the skin. *a*, Fibrous portion of the tendon; *b*, 'Palisades' containing 'torpedo cells'; *c*, The 'blue line'; *d*, The 'armour plate'; *e*, Cancellous bone of the humerus. (*Codman's nomenclature.*) (*By courtesy of Professor G. Lyman Duff.*)

C, Photomicrograph of histological section of normal adult supraspinatus tendon showing the typical arrangement of the wavy collagen bundles and the thin elongated nuclei of fibrous connective-tissue cells. Note the absence of visible blood-vessels. (Hæmatoxylin and eosin.)

D, Photomicrograph of histological section of supraspinatus tendon near its insertion showing advanced stage of degeneration. The fibrillar tendon structure has a loose œdematous appearance. Note the numerous thick-walled arterioles. (Hæmatoxylin and eosin.)

E, Photomicrograph of histological section of the greater tuberosity of the humerus, showing recession following complete rupture of the supraspinatus tendon. At the site of insertion of the tendon there is no remnant of tendon or fibrocartilage, but only a thin layer of loose connective tissue covering the abnormally thin bony cortex. The margin of the articular cartilage is seen at the right side of the photograph. (Hæmatoxylin and eosin.)

When the pain factor has been thus removed the power of attaining and maintaining abduction is tested; and if this is greatly diminished, because of failure to maintain the fulcrum in the gleno-humeral joint, a ruptured cuff can be diagnosed with confidence. If, however, the injection relieves the pain and the range of movement is fully restored and there

is little if any loss of power in the abduction mechanism, a partial rupture can be presumed to be present.

Palpation of the cuff attachment to the tuberosities should then be performed with the arm held in dorsiflexion and adduction to bring the greater tuberosity in front of the acromion. By gentle rotation the bicipital groove is first located. The area of the supraspinatus insertion will then be palpated. In complete ruptures the point of maximum tenderness will correspond to the place where at operation the stub of tendon is found. Medial to this point the sulcus corresponding to the gap of the separated tendon will be discerned by the experienced examiner. Rotation of the humerus will cause the transmission of a soft crepitus to the examining fingers. Palpation will then extend to the bicipital groove and lesser tuberosity, which will present acute tenderness when the biceps and subscapularis are involved. At this time inspection should be directed to ascertain the presence or absence of a prominence of the belly of the long head of the biceps, made obvious by alternating supination and pronation of the forearm against resistance. This may indicate a rupture of this tendon and the patient's history will determine the time of its occurrence.

Further tests to bring out evidence of injury to the cuff can be performed. The patient may be asked to abduct the arm from the side which is resisted by the examiner; or the adducted humerus may be externally or internally rotated against resistance. These movements increase the pain in the shoulder and assist in the confirmation of the diagnosis.

Before the local examination is completed the acromio-clavicular joint should be investigated for local tenderness or evidence of recent injury since this lesion is often confused with injury to the cuff.

The affected shoulder should also be compared with the normal shoulder as a control. In cases of dislocation, differentiation of severe cuff injuries from axillary nerve paralysis must be made by noting the presence of contraction of the deltoid fibres when the patient attempts to abduct the arm against resistance.

The Late Case.—Cases may be seen on the day of the injury or may present weeks, months, or years later, but the characteristic history is usually given by the patient. The pain gradually lessens after a few days and the function improves up to a point where, in severe injuries, it becomes stationary for a prolonged period. Probably early cases should be defined as those seen within three weeks of the accident and late cases as those seen after this period. The time factor of three weeks is arbitrarily taken because after this time secondary changes are becoming demonstrable.

One of these secondary changes of great diagnostic importance is the atrophy of the infraspinatus and supraspinatus muscles which makes the scapular spine prominent. This is as typical for severe ruptures of the cuff as is the wasting of the vastus internus in internal derangements of the knee-joint. It does not occur with calcified deposits and is a differential diagnostic point.

Further secondary changes are concerned with the disuse atrophy of the muscles involved in the abduction mechanism and contracture of the adductor and internal muscles caused by resting the arm in the sling position. This is often due to the treatment prescribed by the medical attendant who advised rest in a sling or with the arm bandaged or strapped by the side. Little atrophy of the major muscles occurs if from the beginning active exercises are given in the stooping or relaxed muscle position.

Another change which should be noted and one which renders operative treatment difficult is the contracture which develops in the cuff muscles themselves, preventing the approximation of the ruptured tendon to its site of insertion.

Observation at operation on cases explored at varying periods after the accident indicates that Nature has her own method of treating these ruptures (*Fig.* 521). The stub of the tendon on the tuberosity is gradually absorbed and the tuberosity recedes, as is seen in degenerative periarthritis. The proximal end of the tendon heals with the formation of a tongue-like edge similar to that found in the regenerated semilunar cartilages. The bursal wall thickens and takes an important part in the repair. Often when explored within the first six months the limitation of movements is caused in great part by this proliferative bursal change, which fixes the deep surface of the deltoid to the area of the reparative process.

In time considerable improvement in function occurs, but the true end-results of proven ruptures of varying degrees have yet to be demonstrated to the writer. From clinical impressions I gather that complete ruptures involving the full extent of the supraspinatus insertion may regain fairly good power and a range of motion up to 140°. The arm, however, is not useful for prolonged work above the horizontal plane and is not equivalent to that obtained by early surgical suture. Further, it requires approximately two years in the younger labourer who suffers this injury to obtain this result.

In the massive avulsions the arm never regains its full power and it is rare to recover movements above the horizontal plane. The joint is subject to recurrent pain on overuse and a high rating of disability is justified. In two cases of dislocation, referred to the author for examination because of severe cuff damage, exploration disclosed rupture of the supra- and infra-spinati, which were bound down in a calcified mass and suture was impossible. Both of these cases when checked after two years were unable to abduct the shoulder above the horizontal plane and the lady supports her elbow with her other hand when fixing her hair.

Complete ruptures of the subscapularis must frequently pass undiagnosed, which would explain the high incidence found in autopsy studies. Some of these cases account for the shoulder pain localized deep to the coracoid which is diagnosed as a ' bicipital syndrome '.

Diagnosis.—*Any patient* 50 *years of age or over, who has a forcible strain or fall injuring the shoulder, and who suffers severe pain with inability to abduct the arm and whose X-ray is negative for fracture, dislocation, or calcium deposits, has almost certainly a rupture of the rotator cuff.*

If the arm can be passively raised to a right angle but falls to the side, your opinion can be further confirmed. Procaine (10 c.c 1 per cent) should then be injected into the area of insertion of the

supraspinatus tendon where maximum tenderness is elicited. If this restores movement, because of removal of the protecting muscle spasm, but the power in maintaining abduction of the arm at 90° against resistance is greatly diminished, the cuff is ruptured and operative treatment must be considered. The differential diagnosis from paralysis of the axillary nerve is readily made as the deltoid will be felt to contract actively. It is almost certain that many cases of extensive cuff ruptures have been confused in the past and diagnosed as axillary nerve injury.

Furthermore, all fractures and dislocations of the shoulder should be considered and examined in the light of possible cuff rupture, and this is especially true if there is a failure to make the normal recovery of the range and power of abduction.

Cases may present weeks or months after the initial injury. The characteristic history will always be obtainable, and in severe injury there will be the further information that there was improvement for a time followed by a severe residual disability. This is indicated by pain on use; limitation of range of abduction and forward flexion; limitation of power in all movements and for practical purposes a uselessness of the arm-trunk-mechanism in the range above the horizontal plane. *The characteristic atrophy of the muscle portions of the supra- and infra-spinati is an important diagnostic point in these cases and is present after three or more weeks, especially in the more extensive ruptures.* X-ray examination often shows cystic changes and roughening of the tuberosities.

TREATMENT

Operative Procedures (*Fig.* 524).—

Anæsthesia.—General inhalation anæsthesia with intratracheal intubation has been the routine method.

Suture Material.—Unabsorbable sutures of No. 2 braided silk are used for the tension and heavy silk for approximation sutures. Multi-filament stainless steel wire is also satisfactory.

Position of Patient.—The supine position with a sandbag under the scapula has been that most frequently employed. Some surgeons have favoured the sitting position with a head-rest. This facilitates the surgical manipulations, but is more difficult from the anæsthetist's point of view.

Incision.—In all cases an exploration is made through a curved skin incision extending downwards from the anterior point of the acromion. The deltoid is split for not more than 2 in. and the bursal roof and coraco-acromial ligament are then exposed. The humerus is rotated and irregularities produced by complete ruptures can often be demonstrated at this stage. The bursa is then opened by longitudinal section of the roof. At this time a careful examination should be made to see whether the anterior reflection of the subacromial bursa is at the anterior border of the supraspinatus or whether continuity exists with the subcoracoid bursa.

Acute Ruptures.—If the case is seen early and the diagnosis of an extensive rupture is certain, nothing is gained by delay, and the principle of treatment should be operative repair at the earliest moment. This is most important when the right shoulder of the right-handed labourer is involved. Naturally operative treatment may be contra-indicated by old age, generalized degenerative changes, especially marked obesity, and cardiovascular disease. The longer the span of active useful life before the patient, the more definite will be the indication for operation. The older sedentary or clerical worker may be satisfied to avoid operation and accept the inferior result of conservative treatment.

If the case is seen early and the diagnosis is doubtful, careful observation of the progress of the case under active exercise therapy should be the course to follow. If improvement in range and power rapidly occurs during the following 3–6 weeks, the surgeon can be content with non-operative measures.

These are the cases which are included under the diagnosis of partial ruptures, but probably include contusions of the cuff, traumatic bursitis, and minor degrees of complete ruptures not justifying operation. An alternative approach in treatment is to rest all such cases in abduction 90°, forward flexion 30°, and external rotation 30°, until the patient can actively raise the arm above this plane. At operation this position is seen to approximate the freshly ruptured cuff, but, as a method of treatment, this procedure seems less definite and certain than accurate suture of the freshened tendon end to raw bone.

Chronic Ruptures.—The diagnosis of the chronic ruptures is made difficult by the secondary changes previously detailed, which include the proliferative process of repair, the disuse atrophy of the tissues concerned, and the adduction–internal-rotation contracture of the shoulder-girdle musculature. If abduction is only obtained by the shrugging mechanism and if the arm can be passively raised by the examiner to the horizontal plane without difficulty, the author considers that exploration and suture at the earliest moment are indicated. These are the cases which in the author's experience present between the second and eighth month after the injury and operative findings have always disclosed extensive ruptures. If, however, there is considerable stiffness of the shoulder, especially when tested in adduction, giving a limitation of external and internal rotation, active exercises under supervision should be arranged for several months before exploration is considered. It is this group of cases which has given me the greatest difficulty, especially when the patient has been out of work for months, and in certain cases exploration has been carried out to ascertain the post-traumatic anatomy in order to save time and money for the individual. Little is lost in such cases of doubt by a split-deltoid incision and exploration of the cuff and bursa. The extent of the cuff rupture is then determined. In many cases the repair can be carried out through this limited incision, and it is the author's experience that more rapid recovery will result if section of the acromion can be avoided. The repair is facilitated in this limited exposure by careful rotation of the humerus into the appropriate position.

In chronic ruptures with retraction, section of the acromion may be required. The usual position of section is shown in *Fig.* 524 and the variations in *Fig.* 528. It is sometimes possible with care to preserve the posterior branches of the supraclavicular nerves, section of which gives anæsthesia to the skin of the inferior flap.

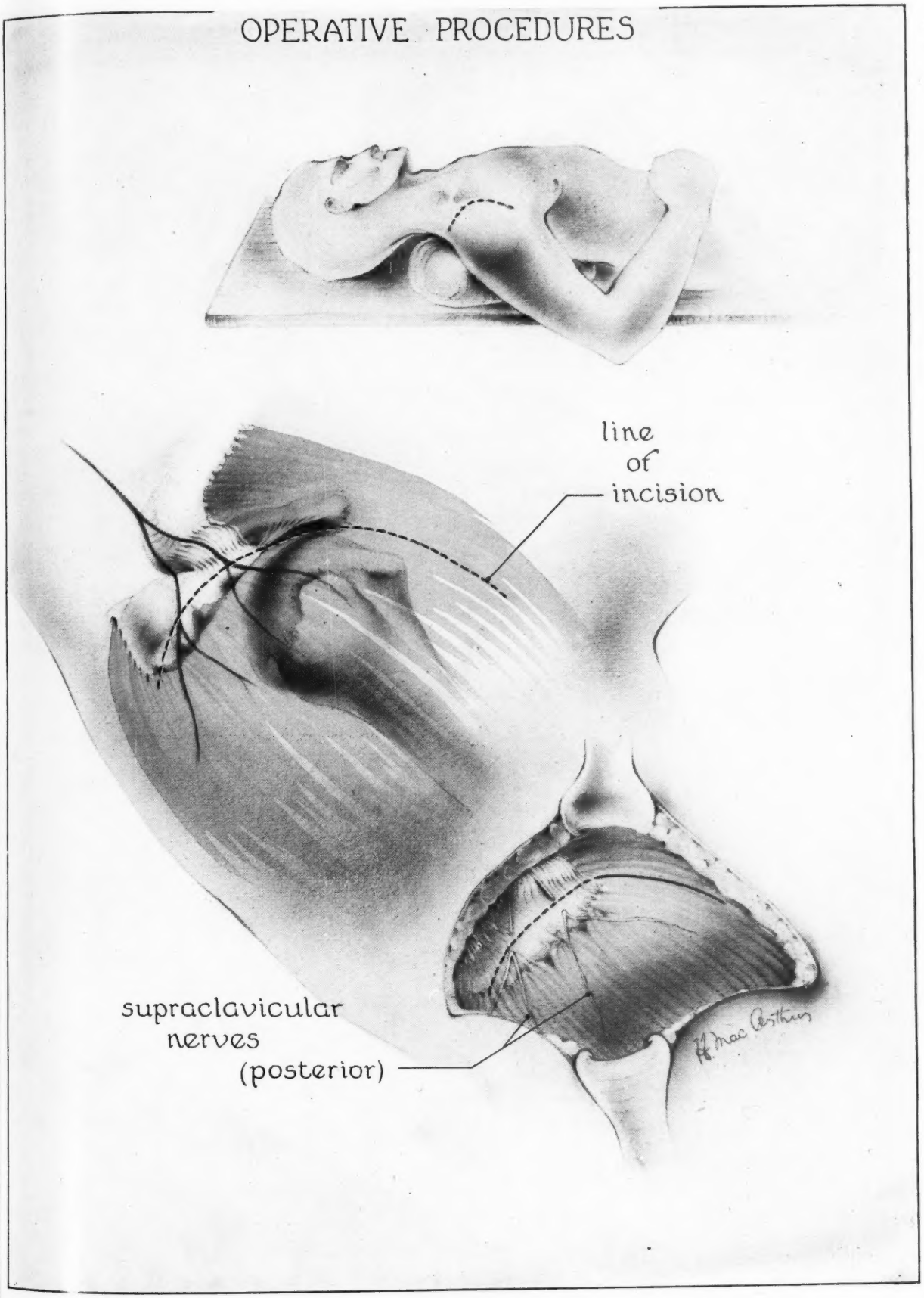

OPERATIVE PROCEDURES
line
of
incision
supraclavicular
nerves
(posterior)

FIG. 524.

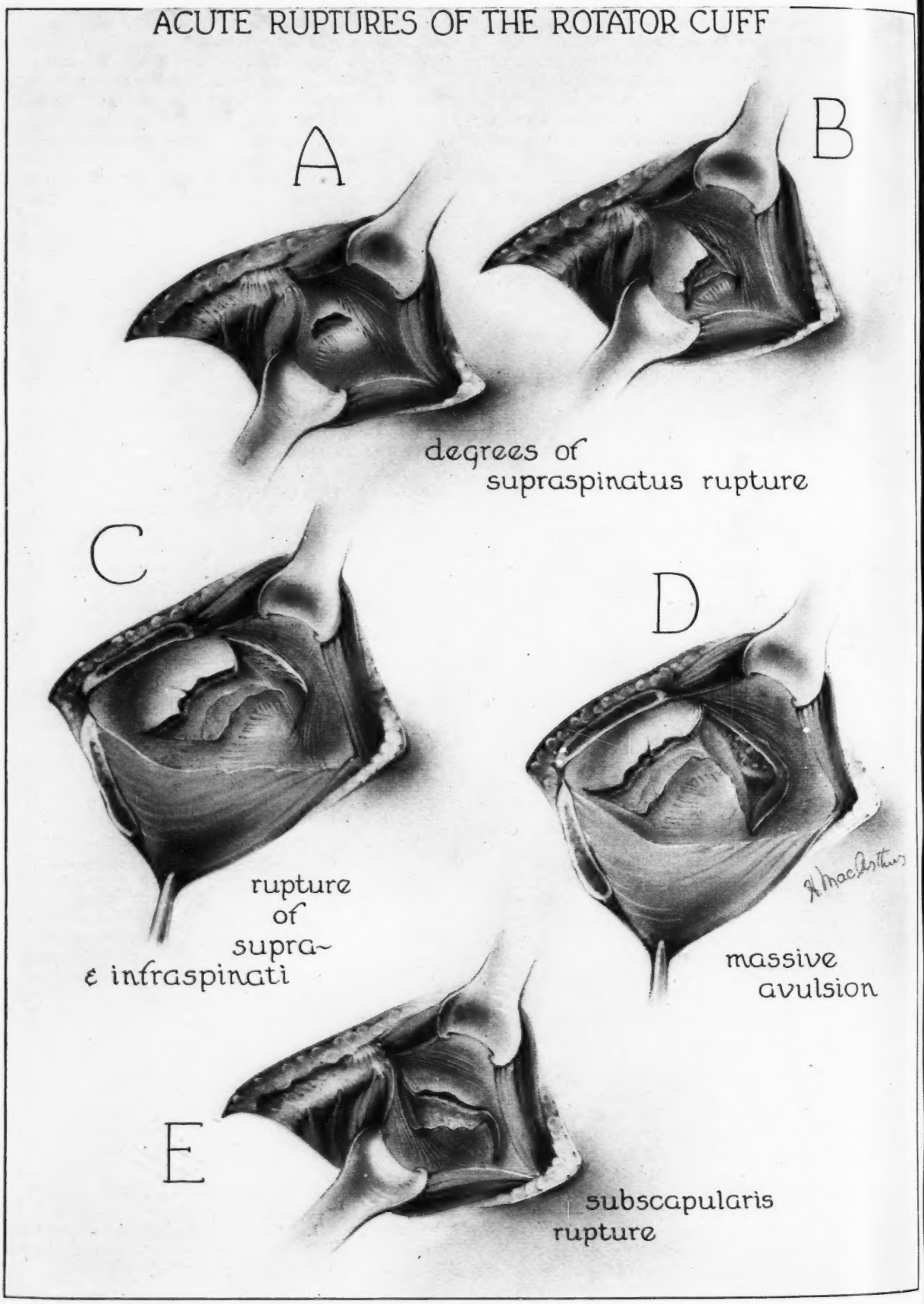

ACUTE RUPTURES OF THE ROTATOR CUFF
A
B
degrees of
supraspinatus rupture
C
rupture
of
supra-
& infraspinati
D
massive
avulsion
E
subscapularis
rupture

FIG. 525.

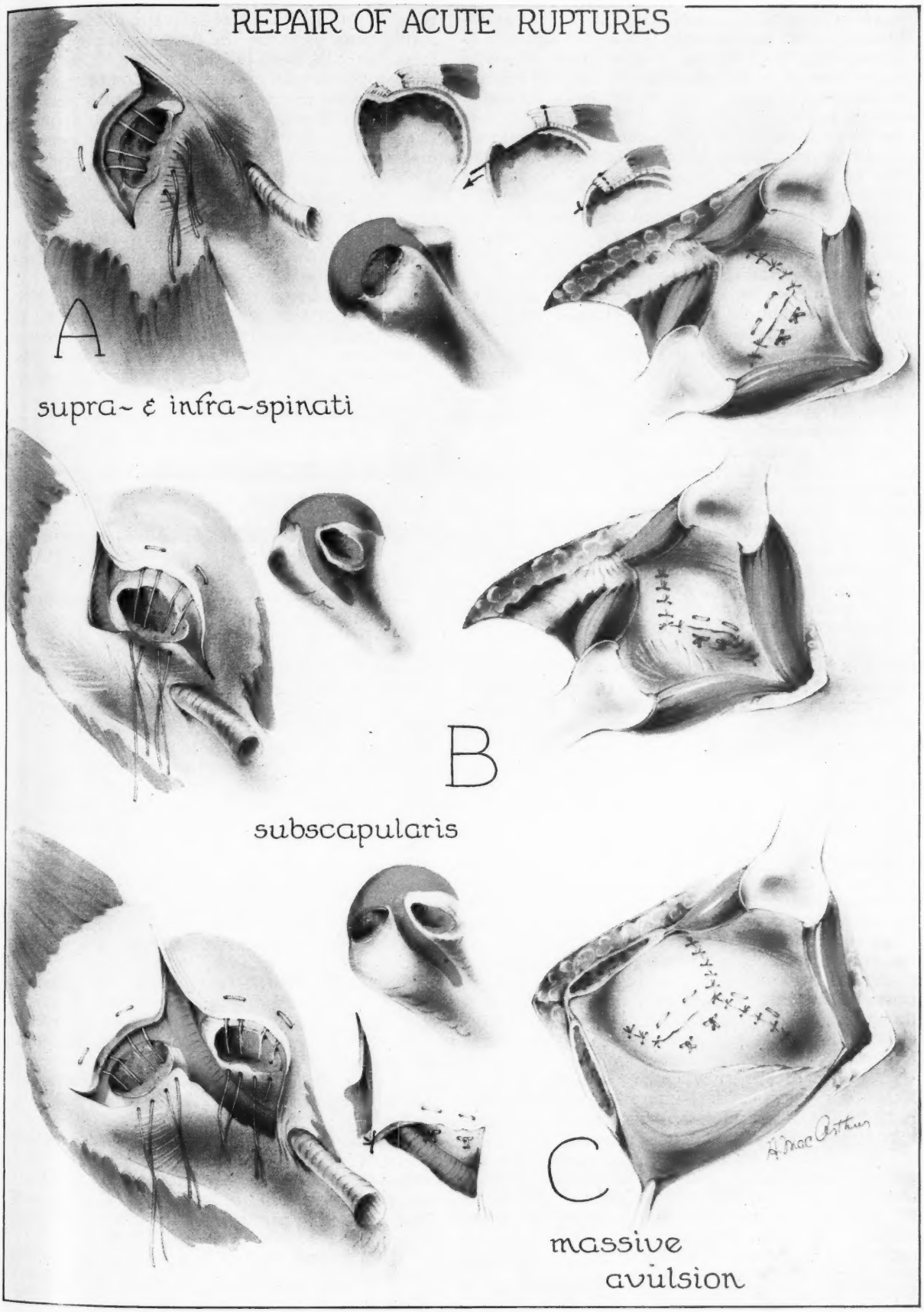

REPAIR OF ACUTE RUPTURES
A
supra~ & infra~spinati
B
subscapularis
C
massive
avulsion

FIG. 526.

The Patterns of Acute Ruptures (*Fig.* 525).—Knowledge of the patterns of acute ruptures is accumulating from operative experience, which is greatly assisted by records made by still and moving picture photography. This is the basis on which accurate medical illustrations can be made. These operative findings differ from those found in anatomical and autopsy studies since the latter are based on cases of degenerative periarthritis, with or without complete ruptures, which are of chronic nature. The patterns in the early cases, when correlated with the findings in shoulders exposed at varying periods of time after the accident, teach us the reparative processes used by Nature and previously described. In the same manner we learn to interpret the extent of the original rupture when the chronic cases are subjected to exploration.

The ruptures in this series are extensive ones and drawing *Fig.* 525 A shows the minimal involvement of the supraspinatus found at operation. In this case, explored on the third day following the accident, a complete rupture involving practically the whole insertion of the supraspinatus was present. If the accident had been more severe, a longitudinal split would have occurred in the cleft between the supraspinatus and subscapularis, giving a triangular flap of cuff which tends to retract posteriorly and medially from the infraspinatus and teres minor contraction, as shown in *Fig.* 525 B. The biceps tendon can be seen if the anterior boundary of defect is retracted forwards.

Further tearing involves the insertion of the infraspinatus and sometimes the teres minor as well. The most posterior point of the tear usually leads to a rent longitudinally placed in the infraspinatus or teres minor (*Fig.* 525 C, D).

A massive avulsion involving the supra- and infra-spinati and also the subscapularis is shown in *Fig.* 525 D. With the avulsion of the subscapularis, this anterior portion of the cuff is drawn forwards, carrying with it the tendon of the biceps, which now courses across the front of the humeral head near the glenoid rim and across the anterior surface of the lesser tuberosity. The bicipital groove is empty and the ligamentous tunnel, which holds the tendon in place, has been completely disrupted. At times, a concomitant acute rupture of the biceps tendon is found with an acute rupture of the supraspinatus, with or without the adjacent portion of the subscapularis tendon.

Rupture of the subscapularis tendon alone is shown in *Fig.* 525 E. This injury is often overlooked because it does not interfere greatly with the abduction of the shoulder, and it is probable that these lesions heal well by natural processes and do not require operation. These cases may result from a temporary, self-reducing dislocation and also occur as part of the post-traumatic anatomy in acute anterior dislocations of this joint. Exploration of recurrent dislocations through the axillary approach may in time teach us more about these injuries.

The Repair of Acute Ruptures (*Fig.* 526).—In acute ruptures it is possible to obtain an anatomical reposition of the torn cuff to its site of insertion, and furthermore to secure the necessary smooth surface from the cuff over the tuberosity. The compact bone, together with the stub of tendon on the tuberosity, is always removed. The author early abandoned the easy method of suturing the torn degenerate tendon to its stub, because follow-up examination disclosed that the repair had probably given way. This has also been my observation on cases which have been repaired in this manner by others. An adjacent area of cartilage is chiselled away and by these measures a considerable area of cancellous bone in the form of a slot is provided into which the tendon is sutured through drill holes in the bone.

The standard repair for fresh ruptures of the supra- and infra-spinati is shown in *Fig.* 526 A. The extent of the slot and the placement of the sutures can be understood by reference to the diagrams. When a fragment of bone or the whole greater tuberosity is avulsed, loose fragments are removed and the bone and cuff are resutured into anatomical position.

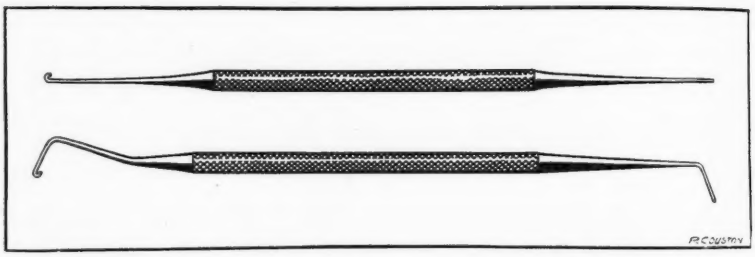


FIG. 527.—Useful instruments for passing sutures through drill holes in bone. (Made by V. Mueller & Co., Chicago.)

The same technique is shown in *Fig.* 526 B for rupture of the subscapularis. This is the easiest type of rupture to repair.

Massive avulsions occur in patients with advanced, degenerative periarthritis, and the cuff is often thin and fibrillated. In the acute case, however, an excellent repair can be obtained. The author does not consider that such cases necessitate arthrodesis of the shoulder. In these cases it is most important to reconstitute the fixation of the biceps tendon in its groove. This is shown in the inset with *Fig.* 526 C. If the biceps tendon is markedly frayed, the intra-articular portion should be removed and the distal end sutured in its groove (*Fig.* 528 B).

When the repair is completed, the humerus is rotated to show the restoration of the anatomical continuity of the cuff and the tension of the sutures is noted with the arm in adduction. I am satisfied that the tension of the suture is not excessive in the acute cases when the arm is in adduction, but agree that it is lessened by placing the arm in the position 90°, 30°, 30°.

Plastic Procedures for Chronic Ruptures (*Fig.* 528).—Operations on chronic ruptures may be carried out within the year following the accident to improve the eventual range of motion and power. After this period pain may be the factor determining operation.

The common type of pattern is shown in *Fig.* 528 A and the smooth healed edge of the tear is apparent. If the supraspinatus or subscapularis alone was originally involved a triangular defect with

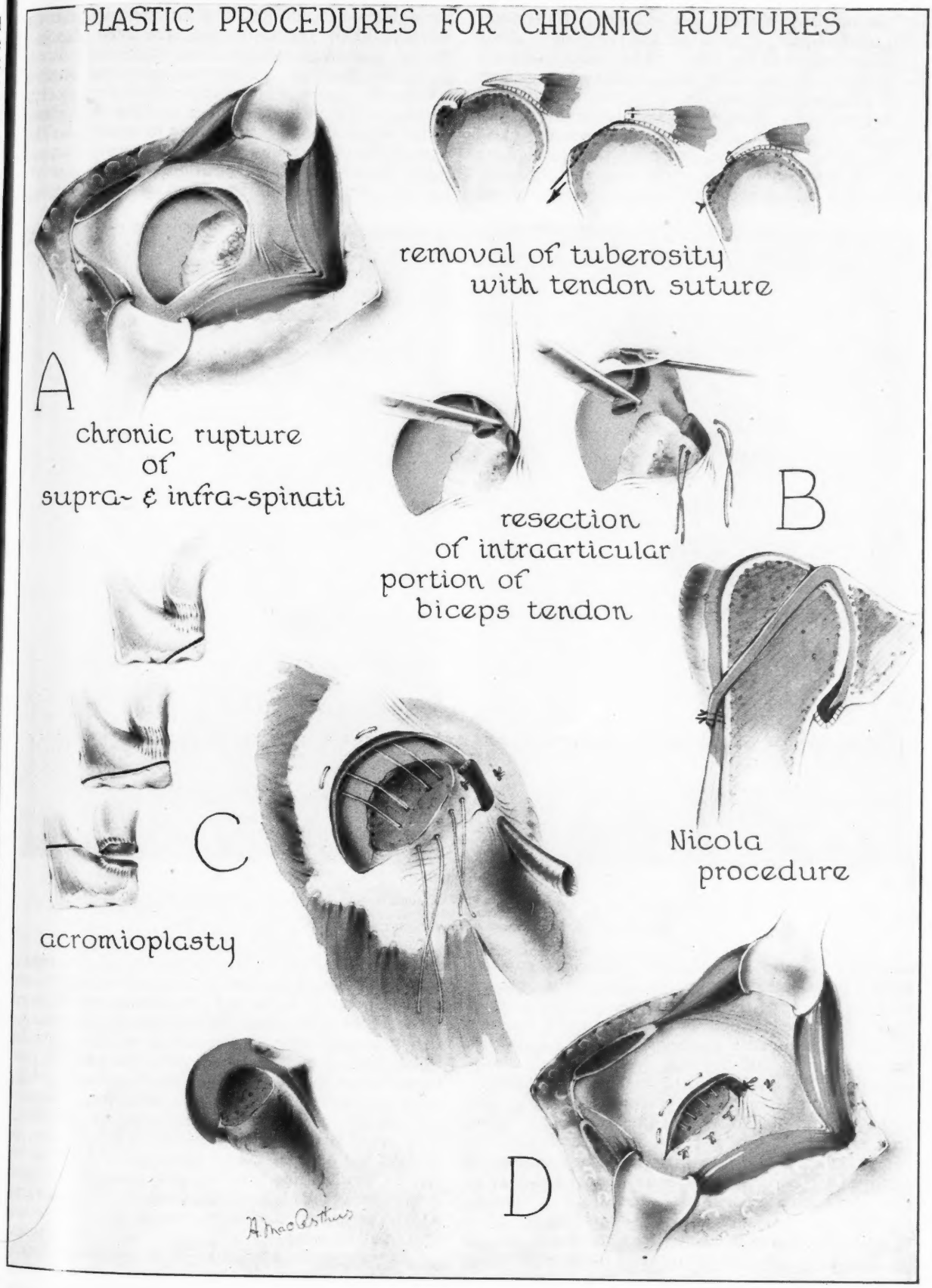
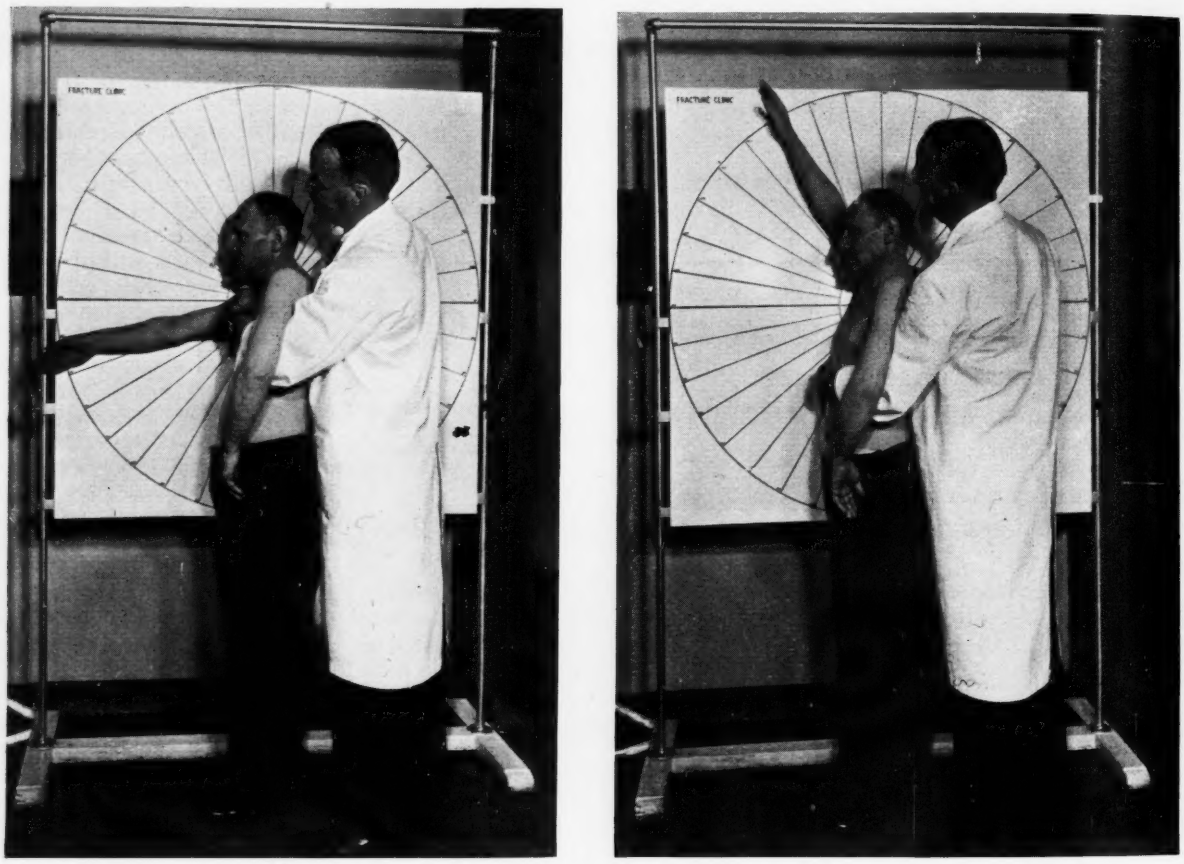

PLASTIC PROCEDURES FOR CHRONIC RUPTURES
removal of tuberosity with tendon suture
A
chronic rupture of supra- & infra-spinati
resection of intraarticular portion of biceps tendon
B
Nicola procedure
C
acromioplasty
D

FIG. 528

its base on the tuberosity will be found. Most cases with marked pain, especially if the radiation is along the flexor aspect of the arm, will be found to have a traumatic irritation of the long tendon of the biceps in its intra-articular portion. This will be indicated by inflammatory thickening and reddening of its synovial sheath and also fraying and wearing away of the tendon itself at its exit from the joint. Late cases of avulsion of the whole greater tuberosity, which may be explored for limitation of power and these cases. It will be noted at operation that the recession of the tuberosity will have taken place to a degree depending on the time which has elapsed since the accident. Complete recession requires about two years. In chronic ruptures accurate anatomical reposition is often impossible and a greater extent of articular cartilage should be removed. This fixation of the tendon to the humerus at a point higher than is the normal position, probably accounts for the limitation in the final 30° of complete



A B

FIG. 529.—A, B, Measurement of forward flexion. A, With clavicle held depressed = shoulder-joint. B, With clavicle free = shoulder-girdle.
Record of this case: Forward flexion joint : girdle = 80° : 150°.

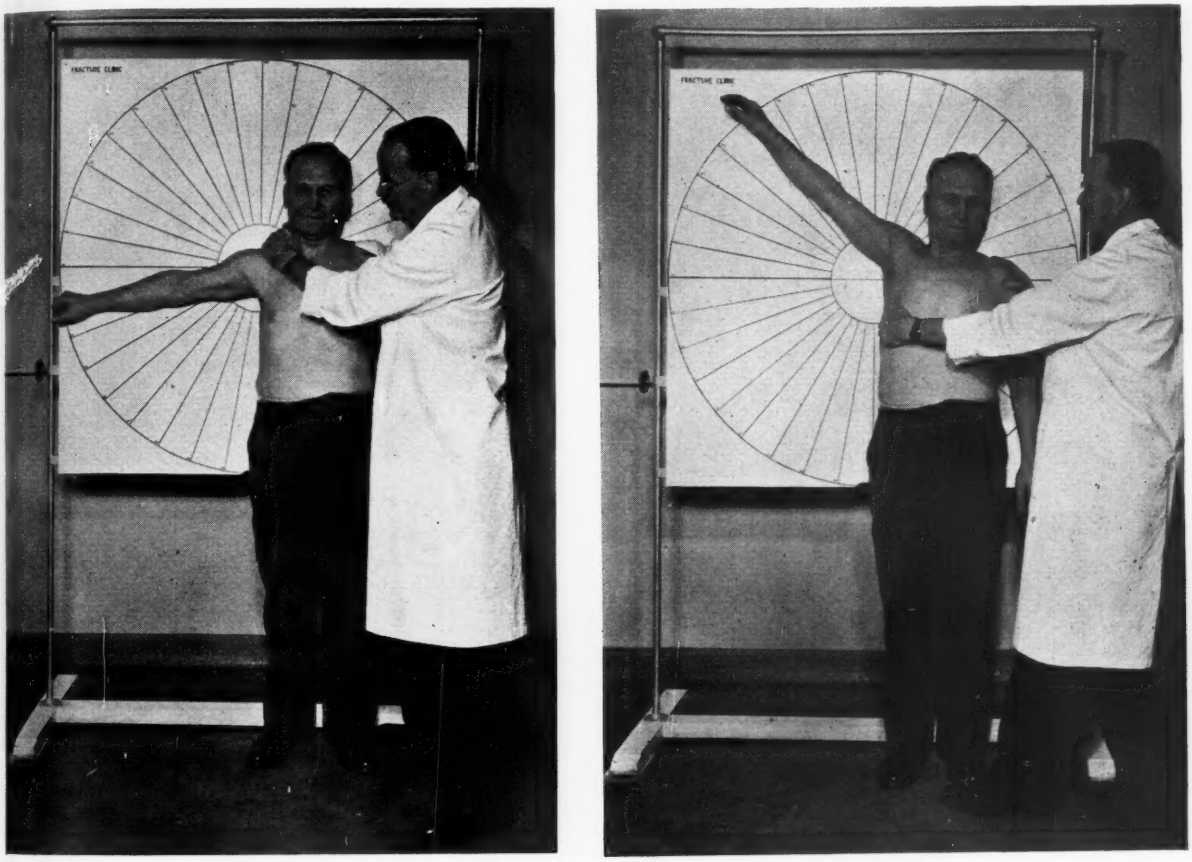
motion, will show the tuberosity malunited so as to leave a large cuff defect of triangular shape over the superior aspect of the humeral head. The sides of this defect are formed by the separated tendons of the supraspinatus posteriorly and subscapularis anteriorly. In all ruptures involving the subscapularis, the tendon of the biceps must be carefully examined, and, if not present in its groove, it will be found dislocated into the front of the joint. In cases where only the cuff is ruptured and the biceps dislocated, the intra-articular tendon is removed. When there has been an associated dislocation, the Nicola procedure is carried out to stabilize the joint, as it is impossible through this exposure to repair the capsular tear at the glenoid rim.

The same principle of suture of freshened tendon to cancellous bone is employed. The greater tuberosity is removed to mirror Nature's method of treating elevation noted in follow-up studies. In the repair, approximation by sutures will be assisted by the use of the thickened bursa and periosteum on the lateral aspect of the tuberosity. The final tying of the sutures is best carried out with the arm at 90°, 30°, 30°. In some of the triangular defects with a long narrow rent extending to the glenoid rim, which are seen chiefly with supraspinatus or subscapularis tears, a side-to-side suture and fixation of the base to cancellous bone is all that may be possible. The elevation of bone at the base must be removed to avoid a sulcus and to give a smooth surface for passage under the coraco-acromial arch. The tension of the sutures should be arranged so as to permit treatment of the arm in adduction.

Repair of the Deltoid.—It is essential to obtain a perfect replacement and suture of the reflected deltoid. When the complete acromion has been

reflected, drill holes in both fragments may be required. The author does not discard this portion of the acromion unless it fragments on section. It appears easier to get perfect apposition with its replacement. The author's experience does not justify an opinion as to whether the complete acromion should be removed in some types of chronic rupture with or without their plastic repair.

Post-operative Treatment.—A pressure dressing is applied at operation which is removed the following day. Early ambulatory treatment is routine. Penicillin (300,000 units) is given for three days. Time in hospital has varied, but averages less than one week.



C D

Fig. 529.—C, D, Measurement of abduction. C, With clavicle held depressed = shoulder-joint. D, With clavicle free = shoulder-girdle. Record of this case : Abduction joint : girdle = 80° : 140°.

Adduction and Abduction.—The problem of immobilization in adduction or abduction has not been resolved. During the winter months in Canada abduction splints and the plaster spica make clinic attendance almost impossible. For this reason these have been employed mostly in repairs of chronic cases where the tension of suture was relieved by the position 90°, 30°, 30° as found at operation. The usual position has been in a sling.

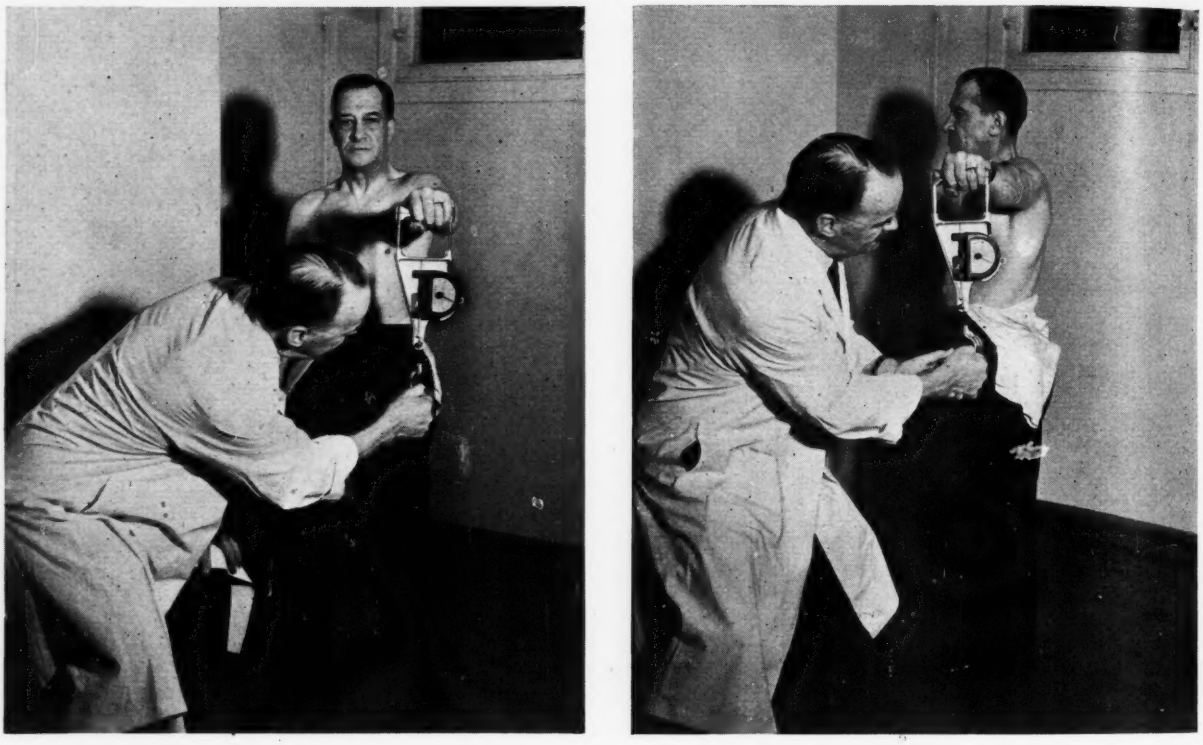
Position of Rest and Motion.—The principle followed in this series is that the surgeon who has carried out the operation must supervise the process of re-education. Gentle forward and backward movements of the arm, and the complete movements of the elbow, wrist, and hand are encouraged from the beginning. Movements of the shoulder itself are gradually begun after three weeks. All movements are initiated by using the relaxed muscle position. *The patient is never permitted to attempt to abduct the arm without assistance for at least six weeks. The weight of the arm would be sufficient to injure the area of repair.* Besides the use of the relaxed muscle position, abduction can be initiated by using the method of Colin MacKenzie. The patient rests supine on a couch and the arm is allowed to slide in abduction and adduction on a smooth surface. In this way the weight of the arm and friction are obviated. It is usually necessary to begin these movements in a position in front of the coronal plane.

Depending on the progress, the next step at four to six weeks is graduation to pulley exercises. Movements in forward flexion are encouraged before those in abduction, and the progress in the range of forward and backward flexion is always in advance of the range obtained in abduction. Every attempt is made to teach the patient movements of the humeral joints and to avoid shrugging the shoulder by using the girdle movements which is the natural tendency.

In time the therapist can employ increasing resistance to the muscles to augment their power, but this should not be an important part of the treatment until after three months. The range of movements is always first obtained before an effort is made to

secure power. Supervision is required for 4–6 months to secure a good result.

When the patient is treated in the position 90°, 30°, 30°, movements above this plane are encouraged and the patient is taught to keep all the muscles of the limb in activity. This position has usually been maintained for six weeks and the case is readmitted for removal of the splint, as this may be painful and the arm should be gradually adducted while the patient is in bed. The programme of re-education



A B

FIG. 530.—Measurement of power. A, Forward flexion 90°; B, Abduction 90°.

should then follow the pattern outlined above. Sometimes a vascular disturbance occurs in the forearm and the hand after removal of the abduction splint. Corrective measures include active exercises of the fingers, hand, and wrist, together with the use of sympathetic block.

Return to Work.—The patient should return to light work for a period of several months before heavy labour is permitted. Depending on his age and the state of degeneration of the cuff, it may be best permanently to avoid heavy lifting and also exertion above the horizontal plane.

Results of Operative Treatment.—Most publications on the results of operative treatment concern repair of chronic ruptures. Codman's series consisted of 31 cases which were sutured, and of these 20 gave good results, 7 fair results, and 4 poor results.

Outland published the results of 12 cases, 7 operated upon within 10 days. Of the 7 acute ruptures, 4 gave excellent results, 3 good results. Of the 5 chronic ruptures, 1 gave a good result, 3 a fair result, and 1 a poor result.

McLaughlin has reported the follow-up of the largest series. This consisted of 100 consecutive cases operated upon in the Traumatic Service of the Presbyterian Hospital. His conclusions are summarized as follows :—

Disability Time.—The pre-operative disability varied from a few days to a few years; the average was about 3 months. The average hospitalization required following repair was about 2 weeks. The average return to light work was 2–3 months after operation depending upon the size of the tear and the efficiency of the repair. Full work followed about a month later.

The Symptomatic Results.—Fifty-six patients had no symptoms; 35 patients had an occasional bad-weather ache as the only symptom—91 patients, therefore, were quite comfortable; 9 patients complained of some other pains.

The Functional Results.—Fifty-six patients had no residual motion defect; 30 patients had an elevation defect of less than 20°; 14 patients had more than 20° defect in elevation and corresponding defects in other motions.

Economic Recovery.—Eighty-three patients returned to their former work; 8 patients did not return to their former work, but were able to resume light work—in general the latter were heavy labourers who suffered massive cuff damage; in 9 cases the record was uncertain about the type of work the patient was able to do.

The Author's Experience.—Careful records have been kept on shoulder lesions for the past ten years. During this period 48 patients have had

complete ruptures of the cuff proven at operation. As has been stated previously, these patients had extensive tears, the minimum involvement being the full extent of the supraspinatus insertion. Partial ruptures have been excluded. There were 43 males and 5 females. One patient had repair of both shoulders for advanced degenerative periarthritis.

Of this series, it has been possible to make an end-result study of 31 cases. The findings are given in the tables and summarized in the case records. It will be noted that the cases are arranged in two groups, 20 acute and 11 chronic ruptures. Three case records relating to the text are appended.

Criteria of Evaluation.—In order that end-result studies on the shoulder may become standardized the following criteria appear to present a satisfactory basis and correspond well to Dr. McLaughlin's principles of evaluation :—

a. Pain : This is the chief symptom and may be the important factor in evaluating the result ; pain or aching on overwork or on working above the horizontal plane, or pain with rheumatic characteristics.

b. Maintenance of Abduction : The capacity to maintain the arm at 90° in the coronal plane is an excellent clinical test of the functional integrity of the cuff and can be compared with the unaffected side.

c. Range of Motion : The range of motion can easily be measured on the protractor in abduction and forward flexion. In this report the girdle is first stabilized as shown in the illustrations to give the indication of the range in the humeral joints and then the range of full girdle movement is estimated. Many patients increase their scapular motion and use trick positioning of the trunk to obviate limitation of motion in the humeral joints. These factors have been eliminated for the most part in this end-result study (*Fig.* 529).

d. Power : The measurement of power is an essential point in the end-result evaluation. This has been estimated in these cases with the spring balance and tensiometer, and the positions taken are those at 90° abduction and 90° forward flexion with strength tested at the hand. This is a very sensitive measurement and gives a much lower reading than when the estimate is made at the level of the elbow. (*Figs.* 530, 531).

Assessment of Results.—It would appear from this study that an end-result could be classified as *excellent* if :

a. Pain : Was absent or only present on prolonged use or was of a mild rheumatic type.

b. Maintenance of Abduction : As tested clinically was practically as good as on the opposite side.

c. Range of Motion : Was above 145° on abduction and forward flexion.

d. Power : Seventy per cent of the unaffected side. The power of the limb will naturally vary in different groups of cases. It has been my practice to advise the patient to avoid heavy lifting, especially above the horizontal plane. This has tended to make the patient favour the limb. There is little doubt that such cases could have the muscles trained to greater power by special exercise therapy.

e. Return to Original Work, or the capacity to do so, would be the final factor.

If the result does not conform to the classification of *excellent*, the terms *good* or *fair* may be used. It does not appear important to delimit these groups carefully as no case should be made worse by operation and the results will either be excellent, improved, or unchanged.

The author's results compare with those of McLaughlin and indicate that in acute and chronic ruptures of extensive degree excellent results are the rule in the absence of complications. Of 18 acute ruptures, 15 were excellent, 3 improved ; of 11 chronic ruptures, 9 were excellent, 2 improved (good or fair). Sepsis has been absent in this series owing in part to the use of chemotherapeutic agents, and this accounts for the improved results as compared with those in Codman's series. (*Tables I, II.*)

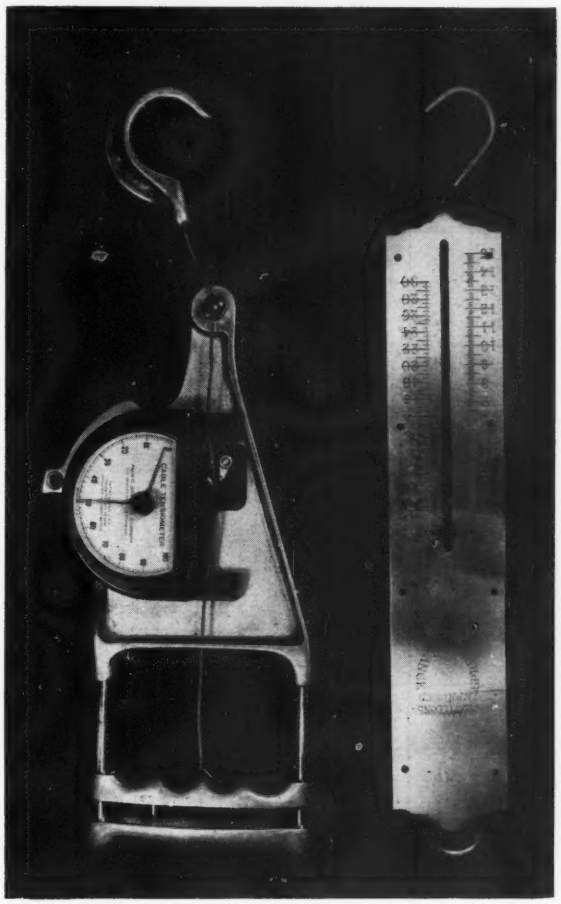


FIG. 531.—Instruments for measurement of power. Spring balance and tensiometer.

It is only possible by clinical impression to indicate that the operative results are far superior to those not subjected to repair. Codman did make a follow-up study on a group of non-operated cases and compared the economic cost to the Compensation Board. Operation in his statistics greatly lessened the economic loss to the community. The future should see this problem finally settled. There is no doubt in the author's mind that the operative treatment of acute and chronic ruptures of the rotator cuff gives results comparable to those obtained from most successful surgical procedures and is the treatment of choice in these cases.

Table I.—ACUTE RUPTURES OF THE ROTATOR CUFF

CASE	SEX	AGE	SIDE	OCCUPATION	PRE-OP. DISABILITY (days)	ACCIDENT	SECTION OF ACROMION	EXTENT OF INJURY	RESECTION OF BICEPS	DAYS IN HOSPITAL	POST-OP. FIXATION	OFF WORK	FOLLOW-UP (months)	RESULT
1	M.	65	R.	Window cleaner	4	Fall	—	Supraspinatus and biceps rupture	+	8	Adduction	12 mth. retired	18	Excellent
2	M.	47	R.	Engineer	10	Lifting 180 lb.	—	Supraspinatus and biceps rupture	+	7	Adduction	4 mth.	37	Excellent
3	M.	57	R.	Riveter	7	Sprain	+	Rupture of supra-spinatus through calcified deposit	—	13	Abduction	3 mth.	42	Excellent
4	M.	45	R.	Baker	2	Fall	+	Supra- and infra-spinati	+	8	Adduction	4 mth.	46	Excellent
5	M.	56	R.	Carpenter	4	Fall	—	Subscapularis, supra- and infra-spinati	Nicola	6	Adduction	9 mth.	51	Excellent
6	M.	54	L.	Mechanic	4	Throwing heavy weight	—	Supra- and infra-spinati	+	12	Abduction	4 mth.	38	Excellent
7	M.	60	R.	Factory worker	6	Fall while carrying heavy weight	—	Supraspinatus	—	9	Adduction	13 mth.	20	Excellent
8	M.	53	L.	Painter	3	Fall	+	Supra- and infra-spinati	—	13	Adduction	3 mth.	27	Good ? excellent
9	M.	64	L.	Foreman	7	Fall	—	Supra- and infra-spinati	—	8	Abduction	2 mth.	36	Excellent
10	M.	56	L.	Waiter	7	Fall	+	Supra- and infra-spinati	—	5	Adduction	4 mth.	61	Excellent
11	M.	56	R.	Engineer	1	Fall	+	Supra- and infra-spinati and subscapularis	—	8	Adduction	2 mth.	16	Fair
12	M.	65	R.	Janitor	6	Fall	—	Supra- and infra-spinati	+	5	Adduction	11 d.	37	Excellent
13	M.	61	L.	Plumber	14	Fall	+	Supra- and infra-spinati	+	14	Adduction	3 mth.	34	Excellent
14	F.	68	R.	Housewife	1	Fall downstairs	—	Supra- and infra-spinati	—	10	Abduction	—	118	Excellent
15	F.	61	R.	Housewife	19	Fall	+	Supra- and infra-spinati	—	14	Adduction	—	20	Good
*16	M.	59	L.	—	7	Fall	—	Supraspinatus	—	—	Adduction	—	10	Excellent
*17	M.	43	R.	Soldier	3	Blow	—	Subscapularis	—	7	Adduction	4 wk.	—	Full army duty
*18	M.	68	R.	Printer	14	Fall	—	Subscapularis	—	7	Adduction	—	24	Excellent
19	M.	67	R.	Hospital porter	1	Fall	—	Supraspinatus	—	12	Adduction	3 wk.	6 wk.	Too early for assessment
20	M.	60	R.	Executive	1	Fall	+	Subscapularis. Supra- and infra-spinati, teres minor	+	10	Adduction	?	3 wk.	

* Cases which by letter reported "complete function present", but did not attend for examination.

Table II.—CHRONIC RUPTURES OF THE ROTATOR CUFF

CASE	SEX	AGE	SIDE	OCCUPATION	PRE-OP. DISABILITY	ACCIDENT	ACROMION RESECTED	EXTENT OF INJURY	INTRA-ART. BICEPS RESECTION	DAYS IN HOSPITAL	POST-OP. FIXATION	OFF WORK	FOLLOW-UP (months)	RESULT
1	M.	60	R.	Locomotive engineer	6 wk.	Fall	+	Dislocated biceps Supra- and infra-spinati	+	13	Abduction	4½ mth.	33	Excellent
2	M.	50	R.	Factory worker	2 mth.	Fall off cycle	—	Supraspinatus and subscapularis	—	7	Adduction	weeks	5	Excellent
3	M.	68	L.	Carpenter	2 mth.	Fall	+	Supra- and infra-spinati	—	14	Abduction	Retired	63	Excellent
4	M.	53	L.	Locomotive engineer	10 wk.	Dislocation of shoulder	+	Supra- and infra-spinati	—	14	Abduction	8 mth.	25	Good
5	M.	57	R.	Cabinet-maker	8 mth.	Fall	+	Supra- and infra-spinati and sub-scapularis	+	6	Adduction	7 wk.	39	Excellent
6(*a*)	M.	67	R.	Clerk	years	Attrition	—	Supraspinatus	+	9	Adduction	weeks	55	Excellent
6(*b*)	M.	68	L.	Clerk	years	Attrition	+	Supra- and infra-spinati	+	10	Adduction	weeks	42	Excellent
7	M.	67	R.	Executive	5 yr.	Fall	+	Supra- and infra-spinati	+	6	Adduction	weeks	24	Fair
8	M.	51	R.	Fireman	2 mth.	Fall	+	Supra- and infra-spinati	—	12	Abduction	—	2	Too early for assessment
9	F.	63	R.	Housewife	5 wk.	Fall	—	Supraspinatus	—	6	Adduction	weeks	8	Excellent ; improving
*10	F.	59	R.	Housewife	6 wk.	Fall	—	Supraspinatus and subscapularis with dislocated biceps	+	5	Adduction	weeks	11	Excellent
*11	M.	64	R.	Farmer	6 wk.	Strain	+	Supraspinatus	+	8	Adduction	3 wk.	22	Excellent

* Cases which by letter reported " complete function present ", but did not attend for examination.

CASE RECORDS

Acute Ruptures of the Rotator Cuff

Case 1.—**Rupture of supraspinatus and long head of biceps, right.**

J. G., male, 65, window cleaner. Fell four days before operation. Anterior split deltoid exposure—intra-articular biceps resected; distal end sutured in groove—supraspinatus repaired. Treated in adduction. Because of age did not return to work, but can do all he wants.

Result (18 months after operation) :—

a. Pain : Occasional ache in damp weather.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 170; Forward flexion 80 : 170.

d. Power : Abduction R. 10, L. 12; Forward flexion R. 10½; L. 15.

e. Classification of Result : Excellent.

Case 2.—**Rupture of supraspinatus and long head of biceps, right.**

R. D., male, 47, engineer. Accident, a sprain while lifting weight of 180 lb. ten days before operation. Anterior split deltoid, intra-articular biceps resected; distal end sutured in groove; supraspinatus repaired. Treated in adduction. Off work four months. Returned to original work.

Result (37 months after operation) :—

a. Pain : Some pain on overwork or on lifting heavy weights.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 60 : 150; Forward flexion 60 : 150.

d. Power : Abduction R. 12, L. 18½; Forward flexion R. 14, L. 15½.

e. Classification of Result : Excellent.

Case 3.—**Complete rupture of supraspinatus through calcified deposit, right.**

D. S., male, 57, riveter. Sprained shoulder one week before operation. Superior approach. Resection of calcified tendon and capsule with plastic repair of cuff. Treated in abduction splint four weeks. Off work thirteen weeks. Returned to former work.

Result (42 months after operation) :—

a. Pain : Can do all work without pain.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 180; Forward flexion 80 : 180.

d. Power : Abduction R. 12½, L. 19½; Forward flexion R. 11, L. 19½.

e. Classification of Result : Excellent.

Case 4.—**Rupture of supra- and infra-spinati, right.**

M. B., male, 45, baker. Fell two days before operation. Superior approach. Intra-articular biceps resected and cuff sutured. Treated in adduction. Returned to his previous work after four months.

Result (46 months after operation) :—

a. Pain : Occasional ache.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 170; Forward flexion 80 : 180.

d. Power : Abduction R. 8, L. 10; Forward flexion R. 9½, L. 16.

e. Classification of Result : Excellent.

Case 5.—**Rupture of subscapularis, supra- and infra-spinati, massive avulsion, right.**

N. B., male, 56, carpenter. Fell four days before operation. Anterior split deltoid exposure. Nicola procedure to biceps. Cuff sutured. Treated in adduction. Returned to full work nine months after operation.

Result (51 months after operation) :—

a. Pain : Can do all work without pain. Avoids outside work during winter.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 75 : 155; Forward flexion 80 : 170.

d. Power : Abduction R. 15½, L. 19; Forward flexion R. 11½, L. 26.

e. Classification of Result : Excellent.

Case 6.—**Rupture of supra- and infra-spinati, left.**

J. B., male, 54, mechanic. Sprained shoulder when throwing heavy weight four days before operation. Anterior split deltoid exposure. Intra-articular biceps resected. Cuff sutured. Treated in abduction four weeks. Returned to former work after operation.

Result (38 months after operation) :—

a. Pain : Left shoulder better than right, which shows signs of marked degenerative periarthritis. Patient has had heart attack.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 70 : 145; Forward flexion 70 : 160.

d. Power : Abduction R. 5, L. 8½; Forward flexion R. 5, L. 7.

e. Classification of Result : Excellent.

Case 7.—**Rupture of supraspinatus, right.**

M. B., male, 60, factory worker. Fell while carrying heavy weight six days before operation. Anterior split deltoid incision. Full extent of supraspinatus ruptured—sutured. Treated in adduction. Returned to work four and a half months after operation.

Result (20 months since operation) :

a. Pain : Some ache on overwork. Can do previous work.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 180; Forward flexion 80 : 180.

d. Power : Abduction R. 12, L. 16; Forward flexion R. 13½, L. 17½.

e. Classification of Result : Excellent.

Case 8.—**Rupture of supra- and infra-spinati, left.**

W. D., male, 53, painter. Fell three days before operation. Superior approach. Intra-articular biceps resected and cuff repaired. Treated in adduction. Returned to previous work three months after operation.

Result (27 months after operation) :

a. Pain : Can do all work without pain.

b. Maintenance of Abduction : Poor.

c. Range of Motion : Abduction 50 : 150; Forward flexion 70 : 170.

d. Power : Abduction R. 10, L. —; Forward flexion R. 8, L. —.

e. Classification of Result : Good. This patient makes no attempt to maintain abduction or strain at the horizontal plane. Subjectively the shoulder is perfect. Hence result classified good—not excellent.

Case 9.—**Rupture of supra- and infra-spinati, left.**

J. H., male, 64, foreman. Fell seven days before operation. Anterior split deltoid exposure. Biceps not sectioned. Cuff sutured. Treated in abduction four weeks. Returned to work two months after operation.

Result (36 months after operation) :—

a. Pain : Aches if he lies on left side too long or if he works above horizontal plane.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 160; Forward flexion 80 : 150.

d. Power : Abduction R. 7½, L. 7; Forward flexion R. 9½, L. 7½.

e. Classification of Result : Excellent.

Case 10.—**Rupture of supra- and infra-spinati, left.**

G. L., male, 56, waiter. Fall seven days before operation. Superior approach. Biceps not resected. Cuff sutured. Treated in adduction. Returned to usual work four months after operation.

Result (61 months after operation) :—

a. Pain : Patient says left arm as good as right—no pain.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 170 ; Forward flexion 80 : 170.

d. Power : Abduction R. 16, L. 19 ; Forward flexion R. 16, L. 14.

e. Classification of Result : Excellent.

Case 11.—**Rupture of subscapularis, supra- and infra-spinati, massive avulsion, right.**

W. W., male, 56, engineer. Fall one day before operation. Superior approach. Massive avulsion easily repaired with biceps resutured in its groove from position of anterior dislocation. Treated in adduction. Returned to work two months after operation.

Complication : Patient developed a severe burn of the anæsthetic lower flap from contact with furnace after return to work. Sinus developed and area of repair was explored four months after operation. Cuff found solidly united to bone—bursa re-forming. Silk sutures were removed and wound healed primarily.

Result : (16 months from first operation) :—

a. Pain : Can do his former work without pain.

b. Maintenance of Abduction : Fair.

c. Range of Motion : Abduction 60 : 100 ; Forward flexion 60 : 130.

d. Power : Abduction R. 6, L. 7½ ; Forward flexion R. 2½, L. 9.

e. Classification of Result : Fair at present and improving each month.

Case 12.—**Rupture of supra- and infra-spinati, right.**

A. D., male, 65, janitor. Fall six days before operation. Anterior split deltoid exposure ; intra-articular portion of biceps removed. Distal end sutured in groove —cuff repaired. Treated in adduction. Returned to work eleven days after operation.

Result (37 months after operation) :—

a. Pain : Doing work without pain. Right arm stronger than left.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 80 : 140 ; Forward flexion 80 : 180.

d. Power : Abduction R. 10, L. 7 ; Forward flexion R. 10, L. 5.

e. Classification of Result : Excellent.

Case 13.—**Rupture of supra- and infra-spinati, left.**

C. M., male, 61, plumber. Fall fourteen days before operation. Anterior split deltoid exposure. Biceps resected and cuff sutured with removal of greater tuberosity. Treated in adduction. Returned to former work 3 months after operation.

Result (34 months after operation) :—

a. Pain : Can do all work without pain.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 70 : 150 ; Forward flexion 80 : 165.

d. Power : Abduction R. 16, L. 14 ; Forward flexion R. 21, L. 15.

e. Classification of Result : Excellent.

Case 14.—**Rupture of supra- and infra-spinati, right. 10-year follow-up.**

E. H., female, 68, housewife. Fall downstairs the day before operation. Anterior split deltoid exposure. Biceps not resected. Cuff sutured. Treated in abduction three weeks.

Result (118 months after operation) :—

a. Pain : Can do all work without pain.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 90 : 180 ; Forward flexion 90 : 180.

d. Power : Abduction R. 2½, L. 4 ; Forward flexion R. 2½, L. 7.

e. Classification of Result : Excellent.

Case 15.—**Rupture of supra- and infra-spinati, right.**

I. McD., female, 61, housewife. Fall nineteen days before operation. Anterior split deltoid exposure. Biceps not resected. Cuff sutured. Treated in adduction.

Result (20 months after operation) :—

a. Pain : Can do all work without pain, but gets ache if she sews a great deal.

b. Maintenance of Abduction : Fair.

c. Range of Motion : Abduction 40 : 110 ; Forward flexion 60 : 140.

d. Power : Abduction R. 3½, L. 8 ; Forward flexion R. 5, L. 10.

e. Classification of Result : Good. Could be improved by further re-education. Patient a heavy-set, overweight person.

Chronic Ruptures of the Rotator Cuff

Case 1.—**Rupture of supra- and infra-spinati with dislocated biceps tendon, right.**

W. B., male, 60, locomotive engineer. Fell six weeks before operation. Superior approach. Intra-articular biceps resected—cuff sutured. Treated in abduction splint four weeks. Returned to his original work four and half months after operation.

Result (33 months after operation) :—

a. Pain : Arm aches if he works for long periods above horizontal plane. Can do all his original work.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 75 : 150 ; Forward flexion 65 : 180.

d. Power : Abduction R. 5, L. 7½ ; Forward flexion R. 9, L. 10½.

e. Classification of Result : Excellent.

Case 2.—**Rupture of subscapularis and supra-spinatus, right.**

J. D., male, 50, factory worker. Fell off bicycle two months before operation. Anterior split deltoid exposure ; biceps not resected. Cuff sutured. Treated in adduction. Returned to light work at an early date.

Result (5 months after operation) :—

a. Pain : Can do original work without pain.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 60 : 140 ; Forward flexion 90 : 160.

d. Power : Abduction R. 7, L. 8½ ; Forward flexion R. 11½, L. 9.

e. Classification of Result : Excellent.

Case 3.—**Rupture of supra- and infra-spinati, left.**

J. S., male, 68, carpenter. Heavy fall two months before operation. Superior approach ; biceps not resected ; cuff repaired. Treated in abduction four weeks. Patient did not return to regular work, but could if he wished.

Result (63 months after operation) :—

a. Pain : No pains or aches in the shoulder.

b. Maintenance of Abduction : Good.

c. Range of Motion : Abduction 40 : 170 ; Forward flexion 40 : 170.

d. Power : Abduction R. 17½, L. 17 ; Forward flexion R. 17, L. 20½.

e. Classification of Result : Excellent.

Case 4.—**Rupture of supra- and infra-spinati with part of teres minor, left.**

H. R., male, 53, locomotive engineer. Dislocated his shoulder in train accident ten weeks before operation. Superior approach; biceps not sectioned; cuff sutured. Abduction splint six weeks. Returned to his original work eight months from accident—five and half months after operation.

Result (25 months after operation) :—

a. Pain: Arm gets tired and aches.

b. Maintenance of Abduction: Fair.

c. Range of Motion: Abduction 55 : 160; Forward flexion 65 : 140.

d. Power: Abduction R. 11, L. 3; Forward flexion R. 12, L. 6½.

e. Classification of Result: Fair to good. Can do original work but lacks power. Would be assisted by physical therapy.

Case 5.—**Rupture of supra- and infra-spinati and part of subscapularis, right.**

J. W., male, 57, cabinet-maker. Fall eight months before operation. Superior approach; intra-articular biceps resected; cuff sutured. Treated in adduction. Returned to work seven weeks after operation.

Result (39 months after operation) :—

a. Pain: No pain on ordinary work. Develops pain if he works above horizontal plane for prolonged periods.

b. Maintenance of Abduction: Good.

c. Range of Motion: Abduction 70 : 170; Forward flexion 70 : 175.

d. Power: Abduction R. 12, L. 18; Forward flexion R. 11, L. 12.

e. Classification of Result: Excellent.

Case 6.—**Bilateral advanced degenerative periarthritis.**

C. McK., male, 67, clerk. Constant pain in both shoulders. *Right shoulder*: Split-deltoid exposure. Attrition rupture of supraspinatus found. Intra-articular biceps removed. Plastic repair to cuff with removal of tuberosity. Treated in adduction. Result so satisfactory returned for operation on left shoulder thirteen months later. *Left shoulder*: Superior approach. Supra- and infra-spinati found worn through. Biceps resected and cuff repaired as on right side. Treated in adduction. *Comparison*: Left shoulder with resection of acromion was much more painful in the post-operative period and required a much longer period of physiotherapy.

Results (55 months and 42 months after operation respectively).—

a. Pain: Some pain if he lies on his left side.

b. Maintenance of Abduction: Good.

c. Range of Motion: Abduction R. 80 : 180, L. 80 : 170; Forward flexion R. 80 : 180, L. 90 : 180.

d. Power: Abduction R. 10, L. 5; Forward flexion R. 8½, L. 7.

e. Classification of Result: Excellent.

Case 7.—**Rupture of supra- and infra-spinati—5 years' duration, right.**

A. R., male, 67, executive. Heavy fall five years before operation—constant pains. Superior exposure; intra-articular biceps removed. Cuff repaired. Treated in adduction. Returned to office duties within a few weeks.

Result (24 months after operation) :—

a. Pain: Patient feels operation has relieved his symptoms and was well worth while. Still gets "rheumatic" pains.

b. Maintenance of Abduction: Good but below that on left side.

c. Range of Motion: Abduction R. 80 : 90, L. 80 : 140; Forward flexion R. 80 : 150, L. 80 : 165.

d. Power: Abduction R. 8, L. 15; Forward flexion R. 9, L. 15.

e. Classification of Result: Fair—operation worth while to patient. Has some pain—his abduction is only to 90° and power just over 50 per cent.

Case 8.—**Rupture of supra-and infra-spinati, left.**

W. S., male, 50, maintenance man. Fell off scaffolding eleven weeks before operation. Superior approach; biceps not resected; cuff repaired; treated in adduction.

Result (65 months after operation) :—

a. Pain: No aches or pains. Can do his original work.

b. Maintenance of Abduction: Good.

c. Range of Motion: Abduction 80 : 165; Forward flexion 80 : 180

d. Power: Abduction R. 19½, L. 15; Forward flexion R. 20, L. 15.

e. Classification of Result: Excellent.

Case 9.—**Rupture of supraspinatus, right.**

Y. B., female, 63, housewife. Fell five weeks before operation. Anterior split deltoid exposure; biceps not resected; cuff easily repaired. Treated in adduction.

Result (8 months after operation) :—

a. Pain: Patient says she can do all her housework without pain.

b. Maintenance of Abduction: Good.

c. Range of Motion: Abduction 60 : 130; Forward flexion 80 : 180.

d. Power: Abduction R. 3½, L. 6; Forward flexion R. 8½, L. 6½.

e. Classification of Result: Good at present; improving and will be excellent if the patient makes any effort to re-educate shoulder above horizontal plane.

Interesting Type Cases

Case 1.—**Concomitant rupture of supraspinatus and biceps, left.**

J. M., male, 65, labourer. Lump in arm and pain in shoulder followed lifting heavy weight, seven days before operation. Anterior split deltoid. Coiled up tendon of biceps found in mid-arm. Replaced in tunnel and sutured. *Supraspinatus sutured to its stub without removal of stub and suture to cancellous bone.* Operation was seen by author and case followed. Patient reported that something gave way six months after operation and arm since then has been very weak and painful. Cannot do his usual work.

Result (45 months after operation) :—

a. Pain: Painful on any continuous work.

b. Maintenance of Abduction: Poor.

c. Range of Motion: Abduction 40 : 130; Forward flexion 50 : 100.

d. Power: Abduction R. 10½, L. 2; Forward flexion R. 12, L. 4.

e. Classification of Result: Poor—painful, weak, and limited in motion. Author has suggested secondary operation.

Case 2.—**Anterior dislocation of shoulder with known rupture of supra- and infra-spinati, right.**

H. R., male, 60, storekeeper. Fell injuring right shoulder seven days before operation. Gross swelling of whole limb, with signs of pressure on brachial plexus and axillary vessels. Open operation through anterior approach. Dislocation reduced. Supra- and infra-spinati torn in almost complete extent and could not be repaired because stitches cut through gelatinous, frayed tissue. Biceps tendon loose in joint passed through head to stabilize joint—Nicola procedure.

Result (36 months after operation in case known to have unrepaired avulsion of supra- and infra-spinati) :—

a. Pain: Aches if he tries to work above horizontal.

b. Maintenance of Abduction: Poor.

c. Range of Motion: Abduction 45 : 120; Forward flexion 40 : 155.

d. Power: Abduction R. 6½, L. 17; Forward flexion R. 5½, L. 19.

e. Classification of Result: Fair. Has no pain. Can do all work below horizontal level. Gets abduction by shrugging shoulder and bending trunk.

Case 3.—**Dislocated shoulder with known unrepaired supra- and infra-spinati, right.**

E. D., female, 62, housewife. Referred to author seven weeks after dislocation reduced because of question of axillary nerve paralysis. Deltoid action present—patient gave all signs of extensive cuff rupture. Operation disclosed complete avulsion of the cuff from the bicipital groove backwards, including teres minor. Whole cuff rolled up in calcified mass and repair was impossible. Nicola procedure performed to stabilize joint.

Result (12 months after operation):—

a. Pain: Aches on overuse.

b. Maintenance of Abduction: None present.

c. Range of Motion: Up to 90° in forward flexion. Has to lift or throw her arm to get abduction.

d. Power: Measured clinically has little power to abduct arm except by trick movements with body. Some power in forward flexion. Has to raise arm and hold it in abduction with good hand to do her hair.

e. Classification of Result: Fair or poor. Indicates function when massive injury to cuff is present.

SUMMARY

1. The surgical anatomy of the cuff and humeral joints has been considered.

2. The process of ageing in the scapulo-humeral joint has been described, and the designation 'degenerative periarthritis' applied to this condition.

3. Degenerative periarthritis is accepted as the basis on which the ruptures of the rotator cuff are superimposed.

4. The clinical picture and diagnosis of the ruptured cuff at different intervals after the accident have been outlined.

5. The patterns of the acute ruptures found at operation, with the later changes due to the reparative processes, have been detailed.

6. The operative procedures for the acute and chronic ruptures of the cuff have been given.

7. Criteria for evaluating the end-results are suggested and the author's cases recorded.

CONCLUSIONS

1. Although extensive ruptures of the rotator cuff do not frequently occur in surgical practice, their diagnosis can be readily made in the acute stage. Nothing is gained in delaying surgical repair once the lesion is recognized. Operative treatment in this group gives almost uniformly excellent results.

2. When seen late, the diagnosis likewise can be made, but the operative repair is more difficult. The end-results in this group are not quite so satisfactory as in the early cases, but certainly justify operative intervention.

The colour plates for this lecture have been produced and published through a generous gift of the Ciba Organization.

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Shoulder Series of Films.*—

No. 581 A.—Surgical anatomy of the shoulder. 2 reels. 31 min. (Dr. H. F. Moseley.)

No. 581 B.—Ruptures of the rotator cuff. 3 reels. 45 min. (Dr. H. F. Moseley.)

No. 581 C.—Anterior dislocations of the shoulder. 3 reels. 41 min. (Dr. H. F. Moseley.)

No. 581 D.—Calcified deposits in the rotator cuff. 2 reels. 30 min. (Dr. H. F. Moseley.)

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PARTIAL GASTRECTOMY IN THE TREATMENT OF BLEEDING PEPTIC ULCER

A REPORT ON FIFTY CONSECUTIVE OPERATIONS

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INCREASING interest has been shown in recent years in the surgical treatment of bleeding peptic ulcer, but few surgeons in this country have yet published their experiences in this field.

Bohn (1949) recorded a series of 33 cases from the Royal Berkshire Hospital, and Tanner (1949) has given the results of his experience, probably unrivalled by that of any other British surgeon, at St. James's Hospital, London.

We now offer an account of 50 consecutive operations at Dudley Road Hospital, Birmingham, for bleeding peptic ulcer in which the treatment has been partial gastrectomy.

The Dudley Road Hospital is an ex-Municipal General Hospital of 850 beds, treating the 'acute sick' and admitting a substantial proportion of the medical and surgical emergencies of the city of Birmingham. Cases of hæmatemesis and melæna due to clinically diagnosed peptic ulcer are admitted at the rate of 140 annually, this number being the average of the admissions for the years 1944 to 1949 inclusive.

THE ROUTINE TREATMENT

All cases of hæmatemesis and melæna are admitted to the medical unit on emergency duty for the day. There are four such units, each in charge of a physican with wide experience of the treatment of this condition. The initial treatment is the same in all four units; mental and physical rest is secured by careful use of sedatives, a purée diet is given, and free use is made of blood transfusion to replace severe loss.

The results of medical treatment at this hospital correspond closely to those reported by Avery Jones (1947), who showed so conclusively that the risk of death from a bleeding peptic ulcer is small in patients with an acute ulcer and in those with a chronic ulcer whose age is under 40 years. After that age the mortality-rate rises steeply and, if bleeding from a chronic ulcer recurs after the institution of medical treatment, it reaches 48 per cent in those with chronic gastric ulcer and 35 per cent in those with chronic duodenal ulcer.

In 1946 our medical colleagues, fortified by the knowledge that we had previously performed gastrectomy with success on three cases of the type that carries this high mortality-rate, decided to submit selected cases to us, and up to the end of 1949 did so on 47 occasions.

SELECTION OF CASES FOR SURGERY

It was agreed that three conditions should generally govern the selection of cases for surgical treatment, and, of these, the first only was considered to be essential. The conditions were: (1) Recurrent brisk bleeding or continuous bleeding after admission to hospital for hæmatemesis or melæna due to (2) a chronic peptic ulcer, the diagnosis being either clinical or supported by previous X-ray or other investigations, in patients (3) aged 40 years or more.

Gordon-Taylor (1946), who has for so long advocated surgical opportunism in the treatment of bleeding peptic ulcer, has stated that "Every case must be considered on its own merits; there can be no hard and fast rules". Following this advice, there has been considerable departure from the strict application of the three conditions in the selection of our cases.

If, in the experienced clinical judgement of our medical colleagues, any case has appeared to be one that would probably terminate fatally on continued medical treatment and has been referred to us, we have agreed to undertake surgical treatment.

The one factor common to all the cases submitted to us for surgical treatment was severe recurrent or continuous bleeding, reducing the hæmoglobin estimation in all the cases in which the estimation was made before blood transfusion to 35 per cent or less. Extreme pallor, restlessness, sweating, and a rapid soft pulse appear in the notes of almost all the cases; air-hunger and mental disturbance are recorded in several of them. The majority of the cases had two or more recognizable recurrences of bleeding after that for which the patient was admitted to hospital and the remaining minority were those cases with continuous bleeding for a period of days.

A tabular list (*Table II*) giving details of the patients in this series is appended; the cases are numbered in chronological order. Those mentioned particularly in the text are referred to by their number in this list.

THE ULCERS FOUND AT OPERATION

Table I shows the site distribution of the ulcers found at operation. The usual preponderance of gastric over duodenal ulcer as the cause of severe bleeding will be noted, the ratio here being approximately two to one.

Table I.—SITE DISTRIBUTION OF ULCERS

AGE DECADE	GASTRIC ULCERS		DUODENAL ULCERS		TOTAL CASES AND PERCENTAGE OF SERIES
	Males	Females	Males	Females	
20–29	1	1	—	—	2 (4%)
30–39	5	—	1	—	6 (12%)
40–49	12	2	8	—	22 (44%)
50–59	6	3	5	—	14 (28%)
60–69	3 1 stomal	—	1	1	6 (12%)
TOTALS	28	6	15	1	50

A chronic peptic ulcer was found to be the source of hæmorrhage and chronicity proved by the presence of fibrosis on microsection in all except 2 cases in which the ulcer responsible for the bleeding was an acute one.

Of these cases with an acute ulcer, one (*Case* 15) gave a history of eighteen months' dyspepsia, and a positive X-ray diagnosis of chronic gastric ulcer had been made a year previously to the onset of hæmatemesis. This led to the erroneous conclusion that his hæmatemesis was due to a chronic ulcer. The other case in which the bleeding was from an acute ulcer was one (*Case* 32) in which an acute ulcer was expected, but a decision to operate was made in spite of this and although her age was only 28 years because she bled continuously for three days and her condition appeared to be desperate. A few years earlier this patient had been in hospital elsewhere with severe hæmatemesis necessitating a number of blood transfusions. She stated that she was kept as an in-patient at this hospital for a year before she was considered to be sufficiently recovered for discharge.

In both these cases microsection showed an acute ulcer of about 0·5 cm. diameter with a surprisingly large eroded vessel in the base.

AGE DISTRIBUTION OF CASES

The average age of the patients in this series was 47·7 years and *Table I* shows the age distribution by decades.

It will be noted that the stipulation that patients submitted to operation should be 40 years of age or more was waived in 8 cases and, of these, the age of 2 fell into the decade 20–29. The reason for the decision to operate on these young patients was the intractability of the hæmorrhage in each case. One of these patients (*Case* 32) has already been referred to as a case in which an acute ulcer was treated by gastrectomy. The other (*Case* 6) was a man of 23 who had a history of dyspepsia of three years' duration terminating in five severe hæmatemeses in the space of ten days and while he was under medical treatment in hospital. The tardy decision to operate in this case was due to his youth.

In 6 cases the age of the patient fell into the decade 30–39 (*Cases* 4, 21, 23, 28, 33, 36), but the severity of the bleeding in each of them appeared to make surgical treatment imperative.

OPERATIVE TREATMENT

Preparation for Operation.—We have usually been asked to see the patient immediately after a recurrent hæmatemesis or melæna, when blood transfusion has already started. The collapsed state of the patients, with pallor, low blood-pressure, rapid soft pulse, moist skin, and anxious expression, makes them appear impossible candidates for any operation.

Transfusion of a blood-volume equal to their estimated loss completely alters their appearance and usually restores the systolic blood-pressure to 100 mm. Hg or more. Hæmoglobin estimations have not been found of much value in assessing fitness for operation.

The rate of transfusion is normally about 70–90 drops per minute, but has been increased considerably in a few cases where blood-loss has been very rapid and appears to be continuing. Too rapid and excessive transfusion results in a general engorgement of the veins and œdema of the tissues, which make the ensuing operation more difficult than it need be and possibly increases the risk of post-operative pulmonary complications.

The patient is brought to the operating theatre with the blood transfusion continuing, and 500–1000 ml. of compatible blood is usually given during and after the operation.

Anæsthesia.—The first 8 cases in this series were operated upon under a local field block and splanchnic infiltration with the addition of nitrous oxide or cyclopropane and oxygen. The method was time-consuming and, in our hands, required such heavy sedation or the use of such amounts of additional inhalation anæsthetic that any advantages due to the use of the local anæsthetic were lost. The remaining cases were given intratracheal cyclopropane and oxygen with minimal amounts of ether or, in a few cases, with curare.

A gastric tube has been passed as soon as possible in all cases. This facilitates the operation considerably by keeping the stomach empty and avoids the risk of regurgitation of fluid which might later be aspirated.

We would stress the necessity for the services of an expert anæsthetist in these cases and we acknowledge our indebtedness to our anæsthetist colleagues who have willingly and skilfully undertaken the difficult and sometimes apparently hazardous task of anæsthetizing these patients.

The Operation.—Partial gastrectomy with preservation of the great omentum was done in all the cases in this series—the first part of the duodenum and the stomach, proximally to within 3 cm. of the cardia on the lesser curvature and at least as far as the lowest of the vasa brevia on the greater curvature, being removed.

When a duodenal ulcer penetrating the pancreas has been found at operation, the duodenum has been separated from the pancreas and the part of the base formed by pancreas has been left behind. Closure of the duodenal stump may be difficult in these cases, but has been safely accomplished after raising a margin of duodenum distal to the ulcer from the underlying pancreas, without resort to the special 'snail' method of closure recommended by Yudin. Any bleeding vessel in the ulcer base has been underrun and the base covered by omentum or peritoneum from the vicinity.

Gastric ulcer bases formed by liver or pancreas have been similarly left behind after detachment of the stomach by cutting through the ulcer margin. Bleeding vessels have been underrun and, where possible, the ulcer base has been covered by peritoneum.

The form of anastomosis used in all cases was that described by Hofmeister with a limited valvular opening into the jejunum made retrocolic in most cases. Occasionally shortness of the transverse mesocolon or other circumstance made antecolic anastomosis preferable.

We do not attribute any virtue to the Hofmeister anastomosis which makes it especially suitable for use in operations for bleeding peptic ulcer. Our preference for this type of gastrectomy is due to our

habitual use of it for elective operations. We find that leakage from the duodenal stump does not occur, post-operative vomiting and symptoms referable to filling of the afferent jejunal loop are very rare, and convalescence generally is easier with this form of anastomosis than it is with any other form which we have used.

Only one case (*Case* 18) of hæmorrhage from a gastrojejunostomy stomal ulcer occurred in this series and here partial gastrectomy included resection of the segment of the jejunum bearing the stoma and was followed by anastomosis of the butt-ended efferent jejunum to the whole width of the divided stomach and union of the afferent jejunum, 'en Y', to the efferent jejunum below the gastrojejunal anastomosis. A similar resection and anastomosis was required in one other case (*Case* 19) in which a gastrojejunostomy had been done about a year previously.

The Impalpable Ulcer.—On opening the abdomen, the presence of blood in the intestines has been obvious and, in most cases, the ulcer responsible for the bleeding has been immediately felt. In 9 cases, however, the ulcer was not immediately palpable either because it was an acute ulcer (*Cases* 15, 32) or because a shallow crater was masked by œdema of the gastric wall and enlargement of glands on the lesser curvature of the stomach (*Cases* 6, 9, 13, 16, 21, 36, 39). In the first four of these cases gastrotomy for inspection and palpation of the gastric mucosa was resorted to and, after more or less prolonged search, the ulcer was either seen or the bleeding vessel was felt, as Bohn says, "like a mustard seed".

Three cases (*Cases* 11, 22, 28) in this series had had laparotomy for hæmatemesis before that for which partial gastrectomy was done. One had been done at another hospital and one of us (K.O.P.) was responsible for the other two. In each case gastrotomy had failed to discover the bleeding ulcer and nothing further was done. These patients all returned within two years with another severe hæmatemesis and, at the second operation, obvious chronic ulcers were immediately found.

The experience of these cases and the prolonged, dirty, and uncertain process of discovery of the ulcer by gastrotomy made us abandon its practice. It seems advisable to us to proceed at once to gastrectomy, even when no ulcer is felt, when laparotomy for hæmatemesis or melæna reveals blood in the intestines, provided that no obvious source of bleeding is found below the first part of the duodenum.

This was done in five cases (*Cases* 16, 21, 32, 36, 39), and in each the ulcer responsible for the bleeding was found subsequently on opening the parts of the stomach and duodenum removed. The eroded vessel in all the cases in which the ulcer was impalpable was found to be of considerable size, having a diameter of up to 1·5 mm., although the ulcer was small and shallow.

Post-operative Treatment.—Blood transfusion during the operation is reduced in rate to 40–60 drops per minute as soon as the stomach is removed and is continued, as mentioned previously, until up to 1000 ml. have been given. This has sometimes been followed by 1000 ml. of 5 per cent glucose in water if the patient appears to be dehydrated or by a similar volume of 5 per cent glucose in normal saline if the urinary chlorides are subnormal.

Tap water by rectal drip is given as a routine for the first three days after operation, after which the increasing oral ingestion of fluids is sufficient to prevent dehydration.

Respiratory exercises, the inhalation of 5 per cent carbon dioxide and 95 per cent oxygen, leg and other movements in bed, and postural coughing when necessary, have all been employed from the first as prophylactic measures against pulmonary and thrombotic complications.

Some degree of chronic bronchitis is almost always found in our urban and industrial population, and, as pulmonary complications constitute the greatest post-operative hazard, penicillin has been given to the majority of the patients until the risk of bronchopneumonia is past.

Ascorbic acid, 200 mg. daily, has been given by injection at first and orally later, when the patient is able to take soft food.

The improvement in the appearance of these patients within 24 hours of operation has usually been noteworthy and gratifying. It has not been uncommon to find them on the day after the operation, with false teeth in situ and glasses on nose, taking an interest in the daily newspaper and anxious only to know how soon they may expect to be able to eat a "proper meal". The convalescence of the successful cases differed in no respect from that of an elective partial gastrectomy and the post-operative stay in hospital was about three weeks.

RESULTS

Of the 50 cases in this series, 43 (86 per cent) were successfully treated by partial gastrectomy and 7 (14 per cent) terminated fatally. The mortality-rate has been disappointingly high and needs consideration. Brief histories of the seven fatal cases follow, in chronological order :—

The Fatal Cases.—

1. *Case* 9. A man of 44, who had had chronic bronchitis and breathlessness on exertion since pneumonia at the age of 19 and ulcer symptoms for two years, was admitted having had a severe hæmatemesis. He was collapsed, Hb 36 per cent, and was given an immediate blood transfusion of 1500 ml. Two days later he had another severe hæmatemesis and was transfused 1000 ml. Persistent melæna followed during the next four days and a further transfusion of 1500 ml. was given. Another severe hæmatemesis then occurred, reducing the hæmoglobin to 33 per cent and operation was advised.

A preparatory transfusion of 1500 ml. of blood was given. Laparotomy, under cyclopropane and oxygen, showed much blood in the stomach and intestines, but no ulcer could be felt. Gastrotomy and considerable search revealed a small chronic mid-lesser curve gastric ulcer. A large vessel eroded in its base bled briskly on being touched.

Gastrectomy was followed by an exacerbation of his bronchitis, and bronchopneumonia was diagnosed on the fourth day after operation. A right basal foul empyema developed and was aspirated on the eleventh and twelfth post-operative days. The patient died on the thirteenth day.

Post-mortem examination showed bronchopneumonia with a right basal lung abscess and empyema to be the cause of death. The abdominal condition was satisfactory.

2. *Case* 20. A man of 57, giving a history of ten years' dyspepsia with a positive X-ray diagnosis of

duodenal ulcer five years ago, was admitted to hospital with acute cholecystitis. Immediately after admission he had a severe hæmatemesis followed by melæna. Hb. 35 per cent. Three days later he had a further severe melæna and was given a blood transfusion of 1000 ml. Melæna recurred 12 hours later and another transfusion of 1000 ml. was given. Large black stools were passed after another 18 hours and the hæmoglobin fell again to 39 per cent. A transfusion of 3000 ml. of blood was given but melæna recurred a day later and operation was decided upon. A pre-operative transfusion of 3000 ml. was given.

Laparotomy showed acute cholecystitis with gangrene of the fundus of the gall-bladder and also a large posterior ulcer of the duodenum, penetrating the pancreas. The gall-bladder was well shut off by omental adhesions. Partial gastrectomy and cholecystectomy were done. The base of the ulcer was not removed, but a very large vessel, probably the gastroduodenal artery, which was eroded, was underrun. A tube drain was left in the right kidney pouch.

The patient died two days after the operation and post-mortem examination showed an early diffuse peritonitis. There was no evidence of any leakage from any of the intestinal suture lines and the cause of the peritonitis was considered to be the gall-bladder infection.

3. *Case* 21. A man of 37 was admitted to hospital a few hours after a moderately severe hæmatemesis and gave a history of gastric ulcer symptoms of 18 months. A severe hæmatemesis occurred 14 hours after admission and a blood transfusion of 1000 ml. was given. The following day hæmatemesis recurred and a further 1500 ml. blood transfusion was given. Sudden collapse two days later was followed by a large hæmatemesis and 2000 ml. of blood was transfused in preparation for operation.

Laparotomy showed much blood in the stomach and intestines, but œdematous glands on the lesser curve and a mass of blood-clot in the stomach made it difficult to feel an ulcer with certainty. A partial gastrectomy was done and, on examining the part removed, an ulcer, 1·5 cm. in diameter with a large vessel open in its base, was found high on the lesser curvature.

The patient died 36 hours after operation. Post-mortem examination showed bilateral bronchopneumonia which, in the opinion of the pathologist, was of more than three days' duration.

4. *Case* 26. A man of 60, with a history of duodenal ulcer for thirty years, was admitted to hospital because treatment at home in bed, under the care of his doctor, for three weeks had failed to relieve a particularly severe exacerbation of his symptoms. He had previously been in hospital for treatment for chronic bronchitis and emphysema. After he had been under treatment in a medical ward for a further three weeks, he had the first of a series of four hæmatemeses with melæna. Three days after the first hæmatemesis the second occurred, and a blood transfusion of 1500 ml. was given. The third bleeding followed one day later and another transfusion of 1000 ml. of blood was given. Two days later the fourth bleeding occurred, and a transfusion of 2000 ml. of blood was given in preparation for operation.

At the operation a posterior duodenal ulcer, 2 cm. in diameter and penetrating the pancreas, was found. Partial gastrectomy was carried out, leaving the ulcer base, in which a large eroded vessel, probably the superior pancreatico-duodenal artery, was underrun. The patient's chest gave trouble from the first, and, six days after the operation, definite signs of consolidation in areas of both lungs appeared. The patient died on the ninth day after operation, and clinically death was due to bronchopneumonia. No evidence of any intraperitoneal trouble was found at any time after the operation.

Permission for post-mortem examination was refused.

5. *Case* 37. A man of 43 was admitted to hospital with melæna. He had had symptoms of a duodenal ulcer for ten years and, for ten days before bleeding started, he had been in bed at home under the care of his doctor. The first melæna occurred 12 hours before he reached hospital, and in that time he had been passing frequent black stools.

Bleeding appeared to be continuous and the patient's condition was so bad that immediate operation was advised. A preparatory transfusion of 2000 ml. of blood was given.

A posterior duodenal ulcer, 2·5 cm. in diameter, was found penetrating the pancreas.

Partial gastrectomy was done, leaving the ulcer base, in which the eroded superior pancreatico-duodenal artery was underrun.

The patient developed signs of bronchopneumonia five days after operation and died on the ninth day. The abdominal condition was satisfactory throughout. Post-mortem examination was refused.

6. *Case* 38. A man of 46, who had suffered from chronic bronchitis for many years, was admitted to hospital after a hæmatemesis of moderate severity. He had had dyspepsia for about a year previously.

Four days after admission he had a severe hæmatemesis followed by melæna, and was given 1000 ml. of blood. On the next day, a very severe hæmatemesis occurred and two transfusions of 2000 ml. and 1500 ml. of blood were given in preparation for operation. Laparotomy showed a chronic ulcer, 3 cm. × 2 cm., on the lesser curve of the stomach. Partial gastrectomy was done.

On the second post-operative day, the patient developed an acute suppurative bronchitis from which he died on the following day.

Post-mortem examination was refused, but there was nothing to suggest anything abnormal in the abdomen following the operation.

7. *Case* 50. A man of 49, with a history of five years' dyspepsia due to a duodenal ulcer, was admitted to hospital immediately after a moderately severe hæmatemesis. The next day he had a severe hæmatemesis and 500 ml. of blood was transfused. Two days later he had another hæmatemesis and was again transfused 1000 ml. of blood. Six hours later a very severe hæmatemesis occurred and a pre-operative blood transfusion of 2000 ml. of blood was given. On opening the abdomen, the stomach was found to be full of blood-clot and a chronic mid-lesser curve ulcer, 2 cm. in diameter and adherent to the pancreas, was felt.

Partial gastrectomy was done.

The patient died five days after the operation and post-mortem examination showed bilateral bronchopneumonia with multiple lung abscesses which the pathologist considered to be of more than five days' duration. The condition of the abdomen was satisfactory.

Discussion of Fatal Cases.—Post-mortem records at this hospital show that very few patients treated medically for bleeding peptic ulcer die as a direct result of blood-loss. The usual cause of death is bronchopneumonia, in the aetiology of which aspiration of vomit, recumbency, and lowered resistance to infection due to exsanguination must all be important factors.

Surgical treatment of bleeding peptic ulcer appears to carry the same hazard; all but one of the fatal cases in this series died as a result of pulmonary complications. There were no deaths from operative shock or from peritonitis due to leakage from either the duodenal stump or anastomotic suture lines.

One death (*Case* 20) was due to peritonitis. This was the case of a man of 57 who had acute

Table II.—Details of 50 Cases of Bleeding Peptic Ulcer in Chronological Order of Operation

Year and Case Number	Sex	Age	Site of Ulcer	Length of History of Dyspepsia	Previous Hæmatemesis or Melæna	Number of Hæmatemeses (H.) or Melæna (M.) Before Operation	Time Interval Between Recurrent Bleedings	Volume (in ml.) of Successive Blood Transfusions	Successful (S.) or Fatal (F.)	Pre-Operative Complications. Previous Operations for Peptic Ulcer. Operation Findings, Post-mortem Findings, and Remarks
944— 1	M.	62	G.	40 yr.	1935 1940	2 H.	12 hr.	1000 1000	S.	Chronic bronchitis, emphysema, chronic 'saddle' G.U. 3 cm. × 1·5 cm. Mid-lesser curve, penetrating liver and pancreas. Large open vessel in pancreas
2	M.	57	G.	12 yr.	—	3 H.	9 hr. 1 d.	1000 2000	S.	Chronic G.U. 2 cm. diameter. Mid-lesser curve. Large open vessel in base
1945— 3	M.	56	G.	¼ yr.	—	2 H.	21 d.	1800 1500	S.	Repeated small bleedings between two severe hæmatemeses. Chronic G.U. high lesser curve reaching cardia, adherent to pancreas and 5 cm. diameter
4	M.	39	G.	4 yr.	—	4 H.	6 d. 13 hr. 24 hr.	2000 1000 2000	S.	Perforated D.U. 1940. Chronic G.U. at incisura, 1·5 cm. diameter, penetrating pancreas. Healed D.U.
1946— 5	F.	57	G.	10 yr.	1936	4 H.	18 hr. 1 d. 3 d.	700 1500 4000	S.	Chronic G.U. high lesser curve, 2·5 cm. diameter. Large open vessel in base
6	M.	23	G.	3 yr.	—	5 H. and M.	1 d. 4 d. 1 d. 4 d.	1000 500 1000 500 2500 1750	S.	Repeated melæna between hæmatemeses. Ulcer impalpable—Gastrotomy. Shallow chronic G.U. high on lesser curve, 2 cm. diameter. Bleeding briskly. Developed lung abscess and empyema after operation. Drained by rib resection
7	M.	43	G.	1 yr.	1946	5 H.	1 d. 5 hr. 2 d. 3 d.	1100 1200 1000 4000	S.	Chronic G.U. mid-lesser curve, 2 cm. diameter. Large open vessel in base
1947— 8	F.	62	D.	1 yr.	—	4 H. and M.	10 d. 3 d. 3 d.	1500 1000 2000 2000	S.	Chronic posterior D.U. 1·5 cm. diameter. Large vessel in base, probably superior pancreatico-duodenal artery
9	M.	44	G.	2 yr.	—	3 H. and M.	2 d. 4 d.	1500 1000 1500 1500	F.	Chronic bronchitis. Persistent melæna between 2nd and 3rd hæmatemesis. Impalpable ulcer. Gastrotomy. Chronic mid-lesser curve ulcer 5 mm. diameter. Large open vessel in base. Death on 13th post op. day. P.M., lung abscess and empyema. Abdomen satisfactory
10	M.	44	G.	4 yr.	1943	4 H.	23 d. 1 d. 2 d.	1750 2000	S.	Chronic gastric ulcer, mid-lesser curve, 2·5 cm. diameter, adherent to pancreas. Stomach distended by blood-clot
11	M.	41	G.	16 yr.	1932 1935	3 H.	1½ d. 3 d.	2000 2000	S.	Laparotomy for hæmatemesis 1945. No ulcer found. Blood in stomach. Impalpable ulcer. Gastrotomy. Chronic gastric ulcer, mid-lesser curve 5 mm. diameter. Large open vessel in base
12	M.	54	D.	6 yr.	—	H. and M. cont.	18 d.	1000 500 2000	S.	Hæmatemesis followed by persistent melæna. Chronic posterior duodenal ulcer, 5 mm. diameter. Open vessel in base
13	F.	48	G.	27 yr.	1943	3 H.	2 d. 2 d.	2000 2000	S.	Blood in jejunum. Impalpable ulcer. Gastrotomy. Chronic mid-lesser curve G.U. obscured by œdematous glands found, 1 cm. diameter. Large open vessel in base
14	M.	43	G.	15 yr.	—	3 H.	1 d. 5 hr.	1500 2000	S.	First hæmatemesis fifteen days after admission for medical treatment for G.U. Chronic G.U. high lesser curve, 2 cm. diameter. Large vessel with tangential erosion in ulcer base

							2 d.	2000		Chronic mid-lesser curve G.U. obscured by œdematous glands found, 1 cm. diameter. Large open vessel in base
14	M.	43	G.	15 yr.	—	3 H.	1 d. 5 hr.	1500 2000	S.	First hæmatemesis fifteen days after admission for medical treatment for G.U. Chronic G.U. high lesser curve, 2 cm. diameter. Large vessel with tangential erosion in ulcer base
15	M.	41	G.	1½ yr.	—	6 H. and M.	1 d. 12 hr. 1 d. 2 d. 2 d.	1500 1500 1000 2000	S.	Blood in stomach and jejunum. Impalpable ulcer. Gastrotomy. Acute G.U. mid-lesser curve 4 mm. diameter with very large vessel open in base
16	F.	52	G.	22 yr.	—	3 H.	2 d. 3 d.	1500 2250	S.	Blood in stomach. Impalpable ulcer. Large glands on lesser curve. Chronic mid-lesser curve G.U. 2 cm. diameter found after gastrectomy. Large vessel with tangential opening in ulcer base
17	M.	44	D.	Many years	—	3 M.	3 d. 4 d.	1500 1500 2000	S.	Perforated D.U. 4 years before. Pyloric stenosis. Chronic posterior D.U., large, penetrating pancreas. Base not removed. Large vessel underrun
18	M.	66	St.	30 yr.	1944 1947	4 H. and M.	1 d. 9 hr. 10 hr.	1000 1500 2000	S.	Gastrojejunostomy, 1930. Marginal ulcer of stoma, 3 cm. × 1 cm. Gastrectomy including stoma
19	M.	51	G.	7 yr.	—	4 H. and M.	1 d. 3 d. 2 d.	2000 2000 2000	S.	Gastrojejunostomy, 1946. Chronic G.U. mid-lesser curve 2 cm. × 1 cm. Large open vessel in base. Gastrectomy including stoma
20	M.	57	D.	10 yr.	—	5 H. and M.	3 d. 12 hr. 18 hr. 1 d.	1000 1000 3000 3000	F.	Bleeding occurred after admission for acute cholecystitis. Gall-stones and gangrene of gall-bladder fundus and large chronic posterior D.U. Very large vessel (? gastroduodenal artery) open in base. Death two days after operation. P.M., general peritonitis; no leakage from suture lines
21	M.	37	G.	1½ yr.	—	4 H.	14 hr. 1 d. 2 d.	1000 1500 2000	F.	Blood in stomach. Doubtfully palpable ulcer. Œdema of lesser curve glands. Chronic G.U. high-lesser curve, with large open vessel in base, found after gastrectomy. Ulcer 1·5 cm. diameter. Death 36 hours after operation. P.M., bronchopneumonia of about 4 days' duration
22	M.	53	D.	15 yr.	1934 1937 1947	3 H. and M.	4 d. 3 d.	1000 2000	S.	Laparotomy for hæmatemesis twelve months previously. No ulcer found (1946). Chronic posterior D.U. 2 cm. diameter, penetrating pancreas
23	M.	37	G.	1 yr.	—	4 H.	3 d. 2 d. 1 d.	1000 1500 1500	S.	Chronic high lesser curve G.U. 1 cm. diameter, with large open vessel in base
1948— 24	M.	56	D	7 yr.	1942	2 M.	10 d.	3000	S.	Chronic bronchitis. Perforated D.U. 1942. Pyloric obstruction. Chronic posterior D.U. 1·5 cm. diameter. Very deformed pylorus. Ulcer base left. Large open vessel underrun
25	M.	56	G.	1 yr.	—	4 H.	2 d. 1 d. 1 d.	750 750 1000 2000	S.	Chronic mid-lesser curve G.U. 2·5 cm. Large vessel with tangential opening in ulcer base
26	M.	60	D.	30 yr.	—	4 H. and M.	3 d. 1 d. 2 d.	1500 1000 2000	F.	Three weeks at home and three weeks in hospital on medical treatment before first bleeding. Chronic posterior D.U. 2 cm. diameter, penetrating pancreas. Superior pancreatico-duodenal artery open in base. Underrun. Death nine days after operation. No P.M. Clinically death due to bronchopneumonia
27	M.	42	G.	5 yr.	—	3 H.	1 d. 1 d.	1000 2000	S.	Chronic G.U. mid-lesser curve, 3·5 cm. diameter. Large open vessel in base
28	M.	36	G.	17 yr.	1946 1946 1946 1947	3 H.	1 d. 3 d.	1000 2000	S.	Chronic G.U. above mid-lesser curve, 2 cm. diameter. Adherent to pancreas. Previous laparotomy for hæmatemesis, no ulcer found, in 1947
29	M.	64	G.	Many years	—	6 H.	1 d. 1 d. 2 d. 3 d.	1500 2000 1500 1500	S.	Chronic high lesser curve G.U. 2·5 cm. × 2 cm. Adherent to pancreas. Large open vesse in base

[*Continued on next page*

Table II.—DETAILS OF 50 CASES OF BLEEDING PEPTIC ULCER IN CHRONOLOGICAL ORDER OF OPERATION, *continued*

YEAR AND CASE NUMBER	SEX	AGE	SITE OF ULCER	LENGTH OF HISTORY OF DYSPEPSIA	PREVIOUS HÆMATEMESIS OR MELÆNA	NUMBER OF HÆMATEMESES (H.) OR MELÆNA (M.) BEFORE OPERATION	TIME INTERVAL BETWEEN RECURRENT BLEEDINGS	VOLUME (IN ML.) OF SUCCESSIVE BLOOD TRANSFUSIONS	SUCCESSFUL (S.) OR FATAL (F.)	PRE-OPERATIVE COMPLICATIONS. PREVIOUS OPERATIONS FOR PEPTIC ULCER. OPERATION FINDINGS, POST-MORTEM FINDINGS, AND REMARKS
1948—										
30	M.	56	G.	8 yr.	1947	M. cont.	1 d. 4 wk.	2000 1500	S.	Hypertension, arteriosclerosis. Persistent slight melæna for four weeks while under medical treatment for G.U. terminating in severe bleeding. Chronic mid-lesser curve G.U. penetrating pancreas, 3 cm. diameter
31	M.	49	D.	10 yr.	—	2 M.	12 hr.	1500	S.	Asthma and bronchitis. Pyloric stenosis. Very large stomach. Large posterior D.U. Much blood in intestines
32	F	28	G.	5 yr.	1945	H. cont.	3 d.	1000 750 1500 2000	S.	In hospital with hæmatemesis, 1945, for one year. Repeated bleeding for three days in this episode. History suggested acute ulcer. Stomach found full of blood. Impalpable ulcer. Acute G.U. 5 mm. diameter found after gastrectomy. Large open vessel in submucosa
33	M	35	D.	16 yr.	1948	5 H. and M.	12 hr. 2 d. 1 d. 1 d.	1500 1500 1250 1000 2000	S.	Chronic D.U. 2 cm. diameter penetrating pancreas. Large vessel, probably superior pancreatico-duodenal artery open in base. Base not removed. Artery underrun
34	M.	48	D.	27 yr.	1935	4 H. and M.	2 d. 10 hr. 1 d.	1500 1500 500	S.	Pyloric stenosis. In hospital two months earlier with alkalosis. Awaiting re-admission for operation. Chronic posterior D.U. 2 cm. diameter. Gross deformity of duodenum. Large stomach
35	M.	46	G.	10 yr.	—	2 H.	6 d.	1000	S.	Pyloric obstruction. Awaiting admission for operation for this when bleeding occurred. Large stomach, full of blood. Pre-pyloric chronic G.U. with three open vessels in base
36	M.	30	G.	10 yr.	1939 1942 1944	4 H.	2 d. 1 d. 1 d.	500 1500 2000	S.	Active pulmonary tuberculosis. Stomach full of blood-clot. Ulcer impalpable. Chronic non-tuberculous G.U., shallow, 2 cm. × 1 cm. on posterior gastric wall found after gastrectomy. Large eroded vessel in base
37	M.	43	D.	10 yr.	—	M. cont.	12 hr.	2000	F.	At home ten days in bed on medical treatment before bleeding began. Chronic posterior D.U. 2·5 cm. diameter. Superior pancreatico-duodenal artery eroded in base. Base left. Artery underrun. Developed broncho-pneumonia five days after operation. Death on ninth day. P.M. refused. Abdominal condition satisfactory throughout.
1949—										
38	M.	46	G.	1 yr.	—	3 H. and M.	4 d. 1 d.	1000 2000 1500	F.	Chronic bronchitis. Chronic mid-lesser curve G.U., 3 cm. × 2 cm. Large open vessel in base. Acute suppurative bronchitis on second post-operative day. Death on third day. P.M. refused
39	M.	46	G.	2 yr.	—	3 H.	1 d. 1 d.	1000 1000 2000	S.	Mitral stenosis. Stomach full of blood. Ulcer impalpable. High lesser curve chronic G.U. found after gastrectomy, 1·5 cm. diameter
40	F.	49	G.	20 yr.	1947	5 H.	2 d. 1 d. 6 d. 12 hr.	2250 1500 1500 2000	S.	Old rheumatic carditis, aortic regurgitation, and mitral stenosis. Chronic mid-lesser curve G.U. 1 cm. diameter, with large open vessel in base
41	M.	40	D.	3 yr.	—	3 H. and M.	8 hr. 4 d.	1500 2000	S.	Pyloric obstruction. Awaiting operation for this. Chronic D.U. penetrating pancreas and ampulla of gall-bladder. Very large stomach
42	M.	52	G.	1 yr.	—	M. cont.	10 d.	500 1000 1000 1000 2000	S.	Continuous melæna for ten days in hospital. Chronic prepyloric G.U. penetrating pancreas. Multiple bleeding points in base
43	M.	43	D.	7 yr.	—	2 M. and H.	1 d.	1500	S.	Perforated D.U. 1947. Pyloric obstruction. Awaiting operation for this. Chronic posterior D.U. with much deformity, penetrating pancreas.

43	M.	43	D.	7 yr.	—	2 M. and H.	1 d.	1500	S.	Perforated D.U. 1947. Pyloric obstruction. Awaiting operation for this. Thread posterior D.U. with duodenal deformity, penetrating pancreas. Moderately large vessel in base under-run
44	M.	42	D.	1 yr.	—	4 M. and H.	3 d. 5 d. 6 d.	1000 1000 1000 1500 2000	S.	Continuous melæna between hæmatemeses. Chronic posterior D.U. penetrating pancreas. Superior pancreatico-duodenal artery eroded. Underrun
45	M.	49	D.	?	—	3 M. and H.	1 d. 1 d. 12 hr.	1000 1500 2000	S.	Chronic posterior D.U. penetrating pancreas. Superior pancreatico-duodenal artery eroded. Underrun
46	M.	51	D.	10 yr.	1948	3 H. and M.	3 d. 18 hr. 1 d.	2000	S.	Chronic posterior D.U. 1·5 cm. diameter, penetrating pancreas
47	M.	44	G.	2 yr.	1948	3 H.	12 hr. 6 hr.	3000	S.	Chronic high lesser curve G.U. penetrating pancreas. Large open vessel in base
48	F.	50	G.	3 yr.	—	4 H.	5 d. 1 d. 1 d.	500 1500	S.	Chronic saddle G.U. lesser curve, penetrating liver anteriorly and pancreas posteriorly 5 cm. × 2·5 cm. Vessel plugged by thrombus in posterior part of crater
49	M.	64	G.	1 yr.	—	3 H.	1 d. 8 hr.	1000 2000	S.	Chronic bronchitis. Perforated D.U. 1949. Chronic prepyloric G.U. 5 cm. × 2·5 cm. penetrating pancreas. Multiple open vessels in base
50	M.	49	G.	5 yr.	—	4 H.	1 d. 2 d. 6 hr.	500 1000 2000	F.	Chronic mid-lesser curve G.U. 2 cm. diameter, adherent to pancreas. Stomach full of blood-clot. Death five days after operation. P.M., bronchopneumonia with multiple lung abscesses of probably more than five days' duration. Abdominal condition satisfactory

cholecystitis, with gangrene of the fundus of the gall-bladder, simultaneously with bleeding from a large duodenal ulcer. Post-mortem examination in this case showed no evidence of the peritonitis being due to leakage from any of the suture lines.

Death in five of the fatal cases (*Cases* 9, 21, 26, 37, 50) resulted from bronchopneumonia, the diagnosis being either a clinical one only or verified by post-mortem examination, and in two of these (*Cases* 9, 26) the patients were known chronic bronchitics. The remaining fatal case (*Case* 38) was that of another known chronic bronchitic in which death, soon after operation, resulted from an acute suppurative bronchitis.

Delay in deciding to operate may have been a cause of the pulmonary complications in all these cases except one (*Case* 37) and this patient had been in bed at home for ten days before continuous hæmorrhage necessitated admission to hospital and immediate operation. In another fatal case (*Case* 26) the initial hæmorrhage occurred after the patient had been in bed under medical treatment for six weeks, but the decision to operate was not made until six days later and after three further severe bleedings. The delay in the other fatal cases ranged from $3\frac{1}{2}$ to 6 days, with recurrences of bleeding from three to five times.

Each successive hæmorrhage and each day of recumbency adds to the risk of pulmonary complications, and especially in patients who already suffer from chronic bronchitis and who eventually urgently need surgical treatment. The post-mortem findings in two cases (*Cases* 21, 50) suggested that bronchopneumonia was already established before partial gastrectomy was undertaken. On the other hand, among the successful cases there were four chronic bronchitics (*Cases* 1, 24, 31, 49), in each of which operation followed immediately after the second hæmorrhage.

Our agreed policy of giving medical treatment a fair trial before deciding to operate for recurrent bleeding has rather tended to bring about the delay in making the decision which we now think most undesirable, especially in patients with chronic bronchitis in whom the risk of delay is greatest. In these patients and in those not admitted for bleeding but in whom hæmorrhage occurs in the course of medical treatment for peptic ulcer, we consider that surgical treatment should follow immediately after the first recurrence of hæmatemesis or melæna.

The mortality-rate in this series might have been reduced by refusal to operate on patients with bronchitis or any other complicating disease, but as these are just the cases in which the risk of death from recurrent bleeding under medical treatment is greatest, we have accepted them for surgical treatment. We have endeavoured to afford as much protection against post-operative pulmonary complications as possible by the physical measures already mentioned and by the use of penicillin. We are now using streptomycin in addition in these cases, in the belief that this may increase the protection, and suggest that the prophylactic use of these antibiotics might be of use in the routine treatment of hæmatemesis.

It may be thought that an operation of less severity than partial gastrectomy might, especially

in ' bad risk ' cases, be advisable for bleeding peptic ulcer, and ligature of bleeding points in the ulcer base or obliteration of the ulcer crater by suturing its margins together suggest themselves as less severe alternatives.

Our experience of these procedures has been small, but we have found them often difficult, prolonged, and far from certain in preventing an early recurrence of hæmorrhage. Even when successful they leave the patient in a condition in which peptic ulceration has previously occurred and is likely to persist. Nothing has been done to prevent a recurrence of life-threatening hæmorrhage at some future date. We have therefore preferred the more radical and, we consider, the easier operation of partial gastrectomy to any ' lesser ' operation in these cases.

CONCLUSIONS

We consider that surgical treatment has a very definite place in the treatment of recurrent bleeding due to peptic ulcer, especially in patients aged 40 or more. Surgery should not be reserved for use as a last resort but should be considered immediately when bleeding recurs in a patient who has been under medical treatment for 24 hours or more, or in whom there is reason to believe that bleeding is continuous.

The more severe the initial hæmorrhage and the greater the liability to pulmonary complications from any cause, the earlier should the decision to operate be made when bleeding recurs.

Partial gastrectomy, in the hands of a surgeon thoroughly familiar with the technique of the operation and with the assistance of an expert anæsthetist, is the most certain and satisfactory method of arresting the bleeding and preventing future recurrences.

The mortality-rate in the cases here reported, though disappointingly high, is less than would have been anticipated had medical treatment been continued.

SUMMARY

1. The treatment by partial gastrectomy of 50 selected patients with recurrent bleeding due to peptic ulcer is reported.

[Since writing this report a further 11 patients with hæmatemesis have been treated by partial gastrectomy with no deaths. The ages of these patients ranged from 37 to 71 years and averaged 54 years.]

2. The criteria used in selecting the patients for operation, details of pre-operative treatment, the type and scope of the partial gastrectomy used, and the post-operative treatment are described.

3. Abridged case-histories of the fatal cases are given and the causes of the mortality in the series are discussed.

4. A table showing the number of patients in the series in each decade of age, with sex and the situation of the ulcer, appears in the text, and a schedule, giving details of each case in consecutive order, is appended (*Table II*).

We would like to express our thanks to our medical colleagues, Drs. May, Hearn, Shepherd, Disney, Gallant, Buchanan, Gillhespy, and Thompson, all of whom have referred cases to us and whose co-operation and interest in the treatment of these patients has been invaluable.

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PRIMARY ACTINOMYCOSIS OF THE BREAST

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THE breast may become infected with *Actinomyces bovis* as a primary lesion, or secondarily by direct spread from the lung through the chest wall. Occasional reports of primary actinomycosis of the breast have appeared over the last fifty years. Their scarcity has stimulated the recording of the following case and a review of the previous literature on the subject. Diagnosis of this condition pre-operatively has been rare, conjectures as to the aetiology have been diverse, and extreme variations in the clinical signs have been observed.

CASE REPORT

HISTORY.—The patient, a nulliparous married woman, aged 27, was referred to out-patients in April, 1949, by her doctor for advice concerning " a persistent and intractable abscess in the left breast discharging through the nipple ". She stated that two years previously she had developed a painful swelling in the left breast behind the nipple. This swelling had lasted one week and had then subsided after a profuse discharge of thick yellow pus through the nipple. The discharge continued intermittently for three months and then dried up. She had remained quite well until March, 1949, when she suddenly developed pain and tenderness of the left breast. The following day there was a discharge of yellow pus from the nipple and she then felt a tender lump in the breast beneath the nipple. The discharge persisted and the lump remained the same size despite fomentations and a course of sulphamezathine prescribed by her doctor. No history of trauma to the breast or nipple was elicited. The infections of childhood had been her only previous illnesses.

CLINICAL EXAMINATION.—The patient looked healthy. She had no gingivitis or obvious carious teeth and there was no abnormality of the neck or jaws. Her heart, lungs, right breast, and abdomen were normal.

Left Breast: Apart from retraction of the nipple, the contour of the breast was unchanged and there was no redness of the skin. An indurated, non-fluctuant, slightly tender mass about 1½ in. in diameter was palpable behind the nipple, to which it was adherent. The mass moved freely on the pectoral fascia. On gently pressing the swelling, a teaspoonful of thick yellow pus

was expressed from the nipple. This pus contained sulphur granules. No enlarged glands were palpable in the axilla.

INVESTIGATIONS.—The pathologist's report on the pus showed that the sulphur granules, as seen in a stained film, were composed of Gram-positive mycelia. Aerobic culture of the pus was sterile, but *Actinomyces bovis* were grown on anaerobic culture. Radiological examination of the chest disclosed no underlying rib or lung disease. There was also no evidence of bony disease of the upper and lower jaws.

A diagnosis of primary actinomycosis of the breast was made and the patient admitted to hospital in May, 1949.

TREATMENT.—This consisted of a course of penicillin parenterally extending over fourteen days and amounting to 4,900,000 units in all. The daily dosage was 350,000 units, this being attained by injections of 50,000 units of penicillin at three-hourly intervals with one night injection omitted.

PROGRESS.—The purulent discharge from the nipple gradually diminished and seven days after the commencement of penicillin no pus or serous fluid could be expressed from the breast. The mass became painless and the patient was discharged from the ward. Over the next two months the mass gradually decreased in size and had finally disappeared by July, 1949. The nipple remained retracted. The physical signs did not alter over the next five months up to December, 1949. She had, however, an occasional slight discharge of clear serous fluid from the nipple. This discharge yielded no growth of *Actinomyces bovis* on culture, but produced mixed growths of staphylococci and streptococci.

PREVIOUSLY REPORTED CASES

Search through the literature has disclosed the following proved cases, all occurring in females. There are no reports of primary actinomycosis of the male breast.

Case 1 (Ammentorp, 1893).—A woman, aged 35, who had been harvesting with the breasts uncovered, developed a painful mass in the breast. The mass was attached to the nipple, which was excoriated. The lungs were normal. The breast was amputated. Cure resulted. The diagnosis of actinomycosis was made from pus in the specimen.

Case 2 (Muller, 1894).—A multipara, aged 34, developed a breast abscess which was opened and pus evacuated. The residual inflammation was poulticed with flax meal and bread and ivy leaves. The wound healed, but two months later broke down, a sinus forming close to the nipple. An indurated mass was palpable attached to the nipple but not to any deeper structures. There were no signs of lung disease. Local mastectomy resulted in cure. Actinomyces was found in the pus post-operatively.

Case 3 (Muller, 1894).—A woman, aged 25, had recurrent breast abscesses for eleven months with a sinus developing close to the nipple. Beneath the nipple a tender, hard mass was palpable. Repeated incisions and curettage over seven months resulted in healing. There were no signs of lung disease. A diagnosis was made from sections of the scrapings.

Case 4 (Von Angerer, reported by Sehrt, 1907).—A girl, aged 24, four months after a confinement developed an acute breast abscess which in due course burst, discharging pus and milk. Incision and curettage did not result in healing, but this was finally attained by mastectomy. The tissue down to the ribs was removed owing to a deep extension of the process. Actinomyces were found in the pus from the curettage. The patient later died of internal actinomycosis.

Case 5 (Sehrt, 1907).—A woman, aged 35, had one year's history of a tender mass in the breast, with a retracted nipple which discharged pus. The mass was not attached deeply. Cure was achieved by local mastectomy. The diagnosis was made from post-operative examination of the pus.

Case 6 (Risel, 1909).—The case was reported to the 13th Congress of the German Society of Pathology meeting in Leipzig, of a woman who had had a mastectomy performed for a hard mass deep in the breast. This mass was thought to be a neoplasm, but was found to be a chronic abscess with actinomyces in the pus. There was no evidence of any other focus in the body.

Case 7 (Langenskiold, 1925).—A multipara, aged 36, had a recurrent abscess in the breast beneath the areola for eight months. This abscess discharged through a sinus close to the nipple on two occasions and healed with poultices of dough and pine resin. A further recurrence of a fluctuating abscess was needled and actinomyces were found in the pus. Healing finally occurred after resection of the affected area.

Case 8 (Langenskiold, 1925).—The patient, aged 31, attended with an abscess of the breast attached to the skin close to the areola and discharging pus through a sinus. The abscess was drained and healing occurred in three weeks. Actinomyces were found in the pus obtained after drainage.

Case 9 (Langenskiold, 1925).—A woman of 47 developed a painless fluctuant swelling in the left breast. The pus obtained by puncture contained actinomyces. Local mastectomy resulted in cure.

Case 10 (Langenskiold, 1925).—A woman, aged 35, developed a red and painful swelling in the breast. It gradually improved with poultices. A small residual indurated circumscribed mass close to the nipple was excised. It was found to be a chronic abscess and the pus contained actinomyces.

Case 11 (De and Chatterjee, 1934).—The patient, aged 35 and multiparous, had had multiple discharging sinuses in her breast for the previous eight years. The whole breast was riddled by these sinuses, and there was great deformity and puckering. Radical mastectomy resulted in cure. The diagnosis of actinomycosis was made from histological examination of the specimen.

Case 12 (Ray and Tribedi, 1938).—A multiparous woman of 35 had had an abscess of the breast one year previously. This abscess pointed below the nipple and multiple sinuses appeared. The breast was shrunken and distorted and the nipple was retracted. The axilla contained enlarged non-indurated glands. The chest was normal on radiological examination. Healing occurred after local mastectomy. The breast was found to be adherent to the pectoral muscles at operation. The diagnosis of actinomycosis was made from histological examination of the specimen.

Case 13 (Pemberton, 1942).—This patient, aged 41, had a seven months' history of a painful swelling in the breast following a sharp grain of corn being stuck in the nipple. The swelling was incised and pus evacuated, but three sinuses formed and the nipple became retracted. There was an indurated and tender mass about the size of a cricket ball in the central part of the breast. It was attached to the skin and to the pectoralis major. An X-ray examination of the chest was normal. Gram-positive mycelia were found in a film of the pus, but no culture was made. Local mastectomy resulted in cure. Some enlarged axillary glands were found to have the appearance of a reactive hyperplasia and were not involved in the actinomycotic process. Histological examination of the specimen confirmed the diagnosis.

AETIOLOGY AND PATHOLOGY

The close anatomical relation of the lesions in the majority of the early cases to the subareolar area, the appearance of the first sinuses close to the nipple, and the actual discharge of pus through the nipple in some cases, support the probability that the portal of entry of the actinomycis is the nipple. In Pemberton's case there was a history of a grain of corn having been stuck in the nipple. An attempt to correlate the disease with straw or grass was also made by Ammentorp, whose patient was stated to have been harvesting with the breasts uncovered. Likewise Muller mooted this possibility, presenting the flax meal with which his patient's breast had been poulticed as an aetiological factor.

Zachary Cope (1949) has epitomized this false idea of infection with actinomyces from grass and straw as a traditional and popular fairy tale, unfortunately being kept alive by fallacious teaching in many text-books.

It is now firmly established that the only actinomycis which commonly causes disease in man is the *Actinomyces bovis* (Israeli) which is micro-aerophilic and is not found outside the human or animal body. Although the *Actinomyces bovis* lurks in carious teeth, contagion in general must be indirect, and Zachary Cope affirmed this in his Bradshaw Lecture of 1949, although he did mention one case where direct infection was caused by kissing.

Direct contact must undoubtedly be considered in cases of primary actinomycosis of the breast. The erotogenic area of the nipple and the patency of its lactiferous ducts, together with the certainty of the presence of *Actinomyces bovis* in the mouths of many adults, is all only circumstantial evidence. However, a similar hypothesis was made by Ray and Tribedi (1938). They stated that in India, where prolonged lactation is the common practice, the suckling child may be old enough for teeth to have erupted. This had occurred in the case which they reported, and they postulated infection of the breast from the infant's teeth.

The general pathological features of the disease in this site do not vary from the characteristics of actinomycosis in other parts of the body. Its spread by direct extension, with recurrent abscess formation, leads to the gross distortion of the breast that is so typical of the late stages of the disease. The adherence of the breast to the deeper structures of the chest wall can be but a prelude to involvement of the thoracic or abdominal cavities and eventual death in the untreated case. Lymph-glands are not usually attacked by the disease since the large size of the organism renders its passage along the lymph-channels difficult. Nevertheless, secondary infection in the sinuses and abscesses may lead to inflammatory enlargement of the glands draining the area. The extreme fibrous tissue reaction of the body to the actinomyces is one of the most remarkable features of the lesion. The consequent comparative slowness of the spread of the process sometimes favours the formation of a chronic abscess mass in the breast.

CLINICAL PICTURE

All 14 cases have occurred in comparatively young women before the age of the menopause, and 5 were stated to be multiparous.

It is clear that the commonest mode of presentation of primary actinomycosis of the breast is as a recurrent abscess. Multiple sinuses and distortion of the breast occur late in the course of the disease. In addition, the natural reaction of the tissues may result in the formation of a hard abscess mass deep in the breast.

Although a similar differentiation of the stages of the disease has been made by Lazzarini (1927), no emphasis has so far been placed on the early manifestations of acute inflammation, and it is considered that a fuller description is desirable.

1. Early Stage—Recurrent Abscess Formation.—Of the 14 cases enumerated, 10 fall within this category. The swelling that forms in the breast is indurated and circumscribed, and in the majority of cases is situated close to the nipple beneath the areola. It extends into the breast tissue and is usually attached to the nipple region. At first it is painless. Later softening occurs and tenderness and all the signs of inflammation develop and increase to give a clinical picture identical with that of a simple breast abscess. This abscess either points close to the nipple, with the formation of a sinus, or may discharge spontaneously through the nipple itself. Very little help may be given by the history in the differentiation of an actinomycotic abscess from a simple breast abscess. In the case reported by the author, signs of inflammation had been present for one week only, and the underlying mass had not previously been noticed by the patient. From the cases enumerated it appears that, following natural or surgical drainage, improvement can be marked. Periods of quiescence of up to two years have been recorded, but eventually recrudescence of inflammation leads to further abscess and sinus formation, with wider and deeper extension of the process.

2. Late Stage—Multiple Sinus Formation with Distortion of the Breast.—Two cases of this stage of the disease are recorded. There is gross deformity of the breast, with cicatrization of the skin, and there are many sinuses present. These sinuses are remarkable for the vascularity of their granulations, notwithstanding the hard fibrous tissue by which they are surrounded. They discharge small quantities of thin pus which is often blood-stained. The breast becomes fixed to the deeper structures of the breast wall by extension of the disease, and may invade the parieties with visceral involvement and death, as in Von Angerer's case. The pitiable condition of the patient has been well described by Mileff (1921). The intermittent discharge of blood and pus and the formation of new sinuses and abscesses continue and are exacerbated by the secondary pyogenic infection that occurs. A photograph of this late stage of the disease has been presented in the article by De and Chatterjee (1934).

3. Quiescent Stage—Chronic Abscess Formation.—In two of the cases reported, a chronic actinomycotic abscess formed a hard mass in the breast. It is not surprising that the hard fibrous tissue of such an abscess may render impossible its clinical differentiation from a scirrhous carcinoma.

DIAGNOSIS

Analysis of the cases shows that the diagnosis was made :—

a. In 4 cases from examination of pus before incision or amputation, the pus being obtained from curettage of sinuses or needling of abscesses.

b. In 10 cases from examination of the pus or specimen after previous incision or amputation.

Examination of the pus is essential in the diagnosis of actinomycosis. While the presence of sulphur granules, as seen in the case reported by the author, is helpful, it is necessary to realize that these granules may not be present, especially in the discharge from chronic sinuses. In addition, *Actinomyces bovis* may be difficult to culture or to find in smears, and repeated attempts may be required before it is isolated. The site of the disease close to the nipple, the acute recurrent abscess formation, and the production of sinuses are cardinal physical signs. The disease may simulate other chronic inflammations or neoplasms of the breast. With these wide alternatives it is not surprising that the diagnosis usually has been made late in the disease, after previous and often repeated surgical interference.

Differential Diagnosis.—Almost all known pathological conditions of the breast could be included in the differential diagnosis.

Emphasis has already been placed upon acute abscess formation as the initial lesion. Misdiagnosis may result from failure to have a full pathological investigation made of the pus whether the disease is in its early or late stages.

The clinical appearances of the late stages of primary actinomycosis of the breast may be identical with the lesions produced by visceral actinomycosis or chronic osteomyelitis of the ribs penetrating superficially. Similarly tuberculosis, syphilis, or chronic non-specific pyogenic infection may produce chronic abscess and sinus formation in the breast and must be excluded. It should be remembered that the sinuses of actinomycosis, with their friable red vascular granulation tissue, are in marked contrast to the pallid lesions of tuberculosis.

In the early stages of a primary actinomycotic abscess, when there is an indurated mass in the breast with no obvious inflammatory features, a diagnosis of neoplasm might appear logical. Similarly, a quiescent actinomycotic abscess may have all the characteristic physical signs of a scirrhous carcinoma of the breast and clinical differentiation will not be easy.

TREATMENT

Analysis of the 13 previously reported cases shows the treatment to have been :—

a. **Local or Radical Mastectomy.**—This was finally performed in 11 cases. Ten were cured and one patient died later from extension of the disease.

b. **Incision and Curettage.**—One case was stated to have been cured by repeated incision and curettage over a period of seven months. One case was apparently cured by simple incision. In neither of these two cases was the duration of cure stated.

In view of the periods of quiescence of up to two years that have been reported, it would seem extremely unwise to rely solely on simple drainage. The sulphonamides, penicillin, streptomycin, and the later antibiotics have now, by their striking therapeutic effect, greatly reduced the need for surgery in the eradication of actinomycosis.

In early stages of the disease, without gross distortion of the breast and multiple sinus formation, mastectomy should not be performed. Adequate drainage of the abscess, combined with prolonged courses of antibiotics or sulphonamides, is generally sufficient to cure. Sensitivity tests will help greatly in deciding which particular drugs should be used. A course of penicillin of the order of half a million units daily for a month may be needed. Streptomycin in daily doses of 1 g. for a similar period, or repeated courses of a sulphonamide such as sulphamezathine or sulphadiazine may be necessary. The development of resistance to an antibiotic is an indication to increase the dose or to change the drug. The latter also particularly applies to the sulpha drugs, which may be used by themselves or in combination with the antibiotics. In general, the duration of treatment will depend on the therapeutic effect achieved, but will need to be maintained for from two to six weeks.

In late stages of the disease, local amputation of the breast, together with proper chemotherapy, would seem advisable. In none of the cases reported were the axillary glands proved infected with the actinomyces, and a classical radical mastectomy is unnecessary.

Prolonged follow-up of all cases will be essential.

SUMMARY

A case of primary actinomycosis of the breast is recorded in which resolution was obtained by parenteral penicillin.

Previous recorded proven cases are reviewed. From these cases three main clinical types are presented :—

1. Early stage of recurrent acute abscess formation.
2. Late stage of multiple sinus formation with distortion of the breast.
3. Quiescent stage of chronic abscess formation.

The aetiology and the pathology are discussed and the possibility considered of direct infection of the breast with *Actinomyces bovis* through the nipple.

The simulation by primary actinomycosis of simple acute breast abscess is stressed, and the differential diagnosis considered.

The place of surgery and chemotherapy in treatment of the disease is discussed.

I wish to thank Mr. H. O. Blauvelt for permission to publish this further case of primary actinomycosis.

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SEPARATION OF A PORTION OF THE LIVER FOLLOWING A GUNSHOT WOUND OF THE ABDOMEN

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ALTHOUGH trauma to the liver is not uncommon, sloughing of liver substance following injury is a rare event. The only instance, as far as can be ascertained, is reported by Ruscoe Clarke (1941). The reason for this probably lies in the extremely good blood-supply that the liver enjoys, derived as it is from both systemic and portal circulations. Injuries which produce a large number of small fragments are, other things being equal, more likely to result in necrosis than are more simple wounds. Yet in Krieg's (1936) series of 60 cases of ruptured liver, 26 were of the " macerating " type, but no mention is made of sloughing of liver tissue either in those who survived or in the cases coming to autopsy.

The present case, a gunshot wound of the liver with associated injury to the stomach, is therefore of interest in that a portion of the liver separated and was extruded spontaneously before final healing occurred.

CASE REPORT

HISTORY.—J. W., male, aged 27, was admitted to the Royal Victoria Infirmary, Newcastle upon Tyne, at midnight on June 20, 1948. One hour previously he had shot himself in the abdomen with a revolver. He was conscious, pale, sweating, cold, and complained of severe abdominal pain. He vomited altered blood after admission. The radial pulse was imperceptible, and respirations were rapid and shallow. The wound of entry was just below the left costal margin, through the rectus muscle, the exit wound being below the eleventh left rib 2 in. from the midline posteriorly. Examination of the chest revealed no pleural damage. Resuscitation was begun, morphine ¼ gr. given intravenously, an intravenous blood-drip started, and a Ryle's tube passed.

AT OPERATION.—After two hours, the blood-pressure being 95/50 mm. Hg and the pulse-rate 120 per minute, it was considered safe to operate. The wound of entry was excised and a left paramedian incision prolonged from it. There was extensive laceration of the left lobe of the liver, with a considerable amount of blood in the peritoneal cavity, though active bleeding had ceased. The stomach high on the lesser curve was torn and the œsophagus at the gastro-œsophageal junction presented extensive bruising from a tangential wound. Exploration restarted bleeding from the liver. Sutures of No. 1 catgut on a large curved Mayo needle were introduced to approximate the edges of the wounds in the liver. Owing to the difficulty of access, hæmorrhage in the region close to the œsophagus was controlled by means of a gauze pack. The tear in the stomach was closed with three interrupted sutures. The abdominal wall was closed around the gauze pack and a drain inserted in the rectus muscle. The operation lasted seventy-five minutes and the patient stood the intervention well. Blood transfusion was continued throughout the operation and afterwards until a total of four pints of blood had been given.

POST-OPERATIVE PROGRESS.—Penicillin, 100,000 units six hourly, was given for twenty days. The pulse-rate fell gradually from 120 to 80 per minute during the first three days. Fifteen hours after operation the patient became dyspnœic and cyanosed. Surgical emphysema was noted above both clavicles, but clinical examination and radiography of the chest revealed no evidence of pneumothorax or of pulmonary collapse. The dyspnœa and cyanosis was probably asthmatic in origin, the patient having a long history of chronic bronchitis and asthma. The condition was relieved by oxygen, and the surgical emphysema gradually disappeared. During the first ten days the temperature fluctuated between 97° F. and 99·6° F. The gauze pack and rubber drain were removed on the third day. On the seventh day blood-stained bile appeared at the upper end of the wound, but apart from this the condition of the patient was satisfactory. All sutures were removed by the tenth day, but twenty-four hours later the wound burst open, and resuture was carried out under local anæsthesia. At this time radiography of the chest revealed a minor degree of collapse of the lower lobe of the left lung. A sudden rise of temperature to 101° F. occurred on the twelfth day and a thick, yellowish, alkaline discharge appeared from the wound on the following day. The wound discharge and a swinging temperature continued for the next nine days, but by the twenty-first post-operative day the temperature was normal, the pulmonary collapse had resolved, and the wound was granulating. On the twenty-fifth day the temperature again rose to 100° F., fluctuating around this level for the next three days, and on the twenty-eighth day three portions of necrotic material, the largest being 2 cm. in diameter, were discharged from the wound. Following this, complete healing took place. The patient was transferred to the convalescent home thirty-three days after his injury.

The wound of exit gave no trouble; it was not excised at operation and healed by first intention under a dry dressing. The pathological report on the extruded material stated : " Histology shows a mass of traumatized bile-stained tissue whose identification is difficult, but it is probably liver." (*Fig.* 532.)

COMMENTARY

Several features in this case are of interest and illustrate important principles :—

1. In 1927 Graham pointed out that liver hæmorrhage is dangerous because the pressure in the portal system is low, and the thin-walled hepatic veins tear easily and gape without retracting or contracting. Moreover, blood mixed with bile coagulates slowly, while the respiratory movements of the diaphragm and abdominal wall produce a continued blood-pressure variation. Spontaneous hæmostasis of a liver wound is therefore unlikely.

On the other hand, Frazer's (1941) opinion is that if one can be satisfied that the wound is restricted to the liver expectant treatment is probably the best, and this attitude has been reiterated by Blackburn and Rob (1945).

In the majority of instances, however, doubt exists as to whether the liver injury is associated with a perforation of a hollow viscus, and this doubt can only be resolved by exploration. Experience is therefore of importance in deciding between operation and conservative treatment.

2. Adequate pre-operative treatment is important for a severe degree of exsanguination can be rapidly corrected by appropriate measures. Blackburn and Rob (1945) found that in their cases of abdominal

injury three pints of blood were usually sufficient to restore blood-loss, and that two hours or more were necessary for the maximum response to be obtained. They point out that operation may have to be undertaken when the blood-pressure is less than 100 mm. Hg, and that intravenous morphine is more valuable than subcutaneous administration. The present case demonstrated the value of these measures.

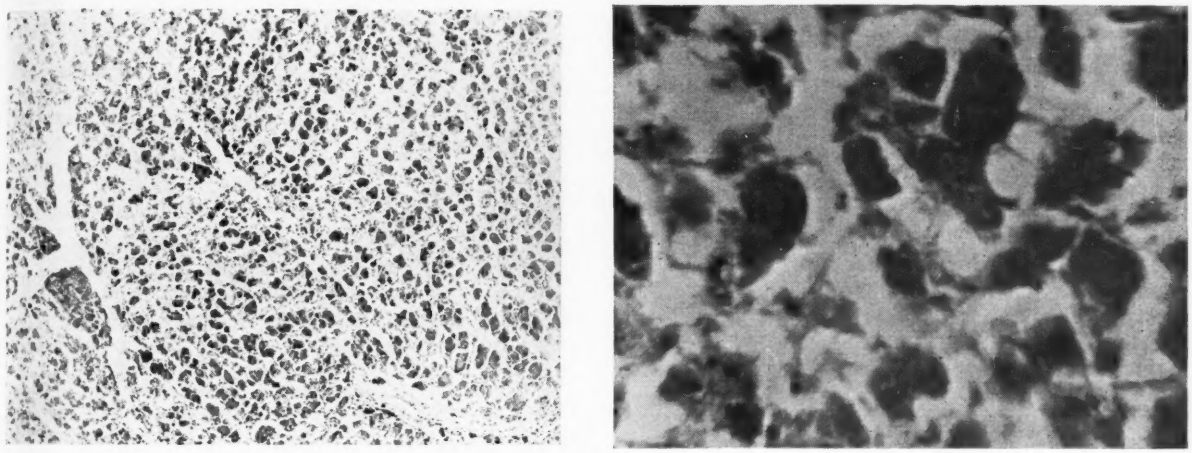
3. Suture is the ideal method of repair of wounds of the liver, though packing has to be resorted to when the injuries are inaccessible or the tissue very friable. Special liver needles are unnecessary, nor is it essential to tie the sutures tightly; this principle applies also to packing. Krieg (1936) stressed the fact that gauze should merely be placed against the wound and not inserted tightly; it thus acts as a scaffolding for clot formation.

4. It is a common practice to leave gauze, which has been introduced to control bleeding, in situ for a week or more; this procedure predisposes to infection, which in turn favours secondary hæmorrhage and delayed healing (Grey Turner, 1940). The question of when to remove a pack is therefore of importance. If hæmorrhage is controlled by the pack the clot should be stable in 48 to 72 hours. After this time leucocytes are attracted to the part and their autolytic agents digest and soften the clot. The mechanical effect of removal of the pack is then more likely to restart bleeding, or this may subsequently be caused by any slight effort, such as coughing or straining. Antibiotics and chemotherapeutic drugs will not prevent leucocytic migration and are thus no guarantee against secondary hæmorrhage on removal of a pack which has been left too long. When removed on the second or third day, the pack is not offensive or soaked in pus as is frequently the case when it is removed at a later date.

There are further arguments in favour of early removal of packing. Gauze placed under or close to the diaphragm is prone to produce pulmonary complications. Pringle (1908) and Lewis and Trimble (1933) report cases of pulmonary consolidation, while the present case and that of Ruscce Clarke (1941) are examples of atelectasis following subdiaphragmatic packing. Pylephlebitis (Woolf, 1934), liver abscess, and peritonitis (Tilton, 1905) may be complications of packing and have been responsible for many deaths, though penicillin is likely to lower the mortality from these latter causes and undoubtedly was of great value in the present case.

The use of absorbable hæmostatic material such as calcium alginate may be the solution to the problem of sepsis when an intra-abdominal pack is required.

5. Separation and extrusion of liver tissue is uncommon. With Clarke's case in mind, a close watch was kept on the wound in the present instance when the discharge began. Clarke attributed "sequestration" in his case to interference with the blood-supply by a transverse tear in the neighbourhood of the portal fissure, plus the presence of a gauze pack. It is more than likely that sepsis was the main cause, as in the present case. Branch (1938) reported an instance in which a fragment of severely traumatized liver, almost entirely separated by a large fissure, was not removed at operation. Drainage was not provided and the patient made an uninterrupted recovery.



A B

FIG. 532.—Photomicrographs of the necrotic liver tissue from the case described in the text. A, Low power (×30); B, High power (×375).

SUMMARY

A case of gunshot wound of the left lobe of the liver with associated injury to the stomach is reported. The method of treatment and avoidance of post-operative complications are discussed.

I wish to thank Mr. Norman Hodgson for the opportunity of treating this case and for his advice and criticism in preparing the paper.

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SHORT NOTES OF RARE OR OBSCURE CASES

SURGICAL TREATMENT OF A CASE OF COARCTATION OF THE AORTA WITH UNILATERAL HYPERTENSION, ASSOCIATED WITH UNGOVERNABLE TEMPERS

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That coarctation of the aorta may exist in the presence of hypertension in one arm and a normal or subnormal blood-pressure in the other, has been observed a number of times (Parkes-Weber and Knop, 1929; King, 1937). Anatomic studies which afford a satisfactory explanation for this difference in pressures are scarce. King (1937) reviewed 170 cases of coarctation and found that there were 10 instances in which a significant divergence existed between the pressures of the two arms. In 9 of the 10 cases there was a higher pressure in the right arm, suggesting that the mouth of the left subclavian artery was involved in the atresia of the coarctation. In the one instance in which there was a higher pressure in the left arm necropsy demonstrated a fibrosis of the right subclavian at its origin from the innominate artery. Three cases of atypical coarctation of the aorta with absence of the left radial pulse were studied by Grishman, Sussman, and Steinberg (1944). They were able to demonstrate by means of angiograms that there was an absence of filling of the left subclavian artery, and they concluded that there was a congenital atresia of the origin of the artery.

The present case is reported for three reasons: (1) An additional example is recorded of coarctation of the aorta in which there is a gross discrepancy in the blood-pressure readings as between the right and the left arms. (2) That this discrepancy was due to a congenital atresia of the left subclavian artery was proved by operation. (3) The abnormal arterial area which included the coarctation area was removed and an end-to-end aortic anastomosis was made.

CASE REPORT

The patient was an 11-year-old boy, who entered hospital complaining of headache and heart trouble. He had been known to have congenital heart disease since he was 6 years old. His growth had progressed normally, and there was nothing suggesting subacute bacterial endocarditis in his past history. He was very active athletically, enjoyed boxing and rugby football, but stated that after strenuous exercise he often had headache and a pain in his left chest, which was relieved by lying down.

The patient manifested an unusual psychological state, for which he was referred to a psychiatrist for an opinion. An extract from his report reads as follows: "The main trouble from the psychiatric point of view is that, since the age of 7, the boy has consistently got into towering rages with his mother. In these he often throws things about, and on two occasions attacked her violently. He has, by these temper-tantrums, established a real reign of terror in the home circle and has enabled himself to gain complete mastery.

"His mother dates his defiance, hatred, and rages from the time when he was forbidden swimming, cycling, and games on account of otitis media at the age of 7."

Violent tempers have been previously noticed by the authors in children with coarctation of the aorta.

Upon Examination.—He appeared to have developed normally. There was a heaving impulse in the base of the neck and in the carotids, synchronous with each heart-beat. The visible collateral circulation seemed to be restricted to the right side. There was a visible tortuous pulsating vessel in the right upper epigastric area. On the back, visible collateral vessels could be seen pulsating in the right shoulder and scapular region, but none was visible on the left side. The right axillary, brachial, and radial pulses were full and bounding, while the corresponding ones on the left side were weak. There were no palpable femoral, popliteal, or dorsalis pedis pulses. Examination of the heart revealed an apex-beat in the 5th interspace, 3 in. from the midline.

The area of cardiac dullness was slightly enlarged. On auscultation the aortic second sound was unusually loud and a systolic murmur was heard loudest at the aortic base and conducted into the neck. A soft diastolic murmur was heard loudest to the left of the sternum in the 4th and 5th interspace. The systolic murmur could be heard widely over the chest in the interscapular region.

The blood-pressure in the right arm averaged 200/110, while that in the left arm was 110/90. The electrocardiogram showed a normal axis with a diphasic T2 and T3. Angiographic studies revealed poor visualization at the junction of the arch and descending aorta and the descending aorta could not be seen. Late filling of the pulmonary artery suggested a patent ductus arteriosus. A shadow in the left upper mediastinum suggested the presence of an aneurysm.

At Operation (May 13, 1949).—Cyclopropane anæsthesia with an endotracheal tube was used throughout the operation. Access was gained into the thorax through the bed of the left fifth rib. When the pleura had been freed from the great vessels it was found that the aorta gave off a large innominate artery, followed by a gradual narrowing of the aorta to the origin of the left common carotid (*Fig.* 533). This vessel had undergone aneurysmal dilatation in its proximal portion, accounting for the shadow seen in the radiographs. Beyond the left common carotid the aorta gradually tapered down to the ductus arteriosus. There was a faint thrill in the pulmonary artery at the end of the ductus, suggesting the presence of a small opening into it. A vestigial left subclavian artery with a fibrous origin of only 3 mm. arose from the site of the coarctation; it gradually enlarged towards the apex, where it had pulsation. Apparently no blood was passing through the coarctation.

It was decided that it might place too great a load upon the heart to occlude the left common carotid during the vascular suture; furthermore, in this instance we were uncertain about the effect on the cerebral blood-supply of long occlusion of the carotid. By utilizing a clamp of the Pott's type it was possible to allow a small amount

of blood to pass into the carotid, and permit enough cuff for a vascular suture. There was a disparity between the size of the proximal and distal ends owing to the narrowness of the aorta at this point. The intervening segment of ductus, coarctation, and the fibrous origin of the subclavian were cut from the great vessels. The distal end of the ductus was closed with a continuous arterial suture. The aortic ends were united with a continuous everting suture of 00000 Deknatel. After removal of the clamps the distal segment pulsated synchronously with the proximal. The mediastinal pleura was approximated, and the thorax was closed in layers. Upon his return to the ward femoral pulses could be felt on both sides.

Examination two months post-operatively revealed a blood-pressure of 140/90 in the right arm, and 110/80 in the left, and femoral pulses were palpable.

Discussion.—The patient had given no history of any limitation of his cardiac efficiency before operation and appeared to remain equally active afterwards. Soon after the operation his temper was still violent. One month later it was stated that he was still at times uncontrollable, using abusive language towards his mother, and in spite of being told to live a quiet life, he had played games and, if anything, overexerted himself.

Five months later it was stated that his behaviour control had very markedly improved. The chief physical effects of the operation have been that the collateral circulation previously widespread over the right thorax had nearly disappeared. One small artery was visible in the 6th right interspace 1½ in.

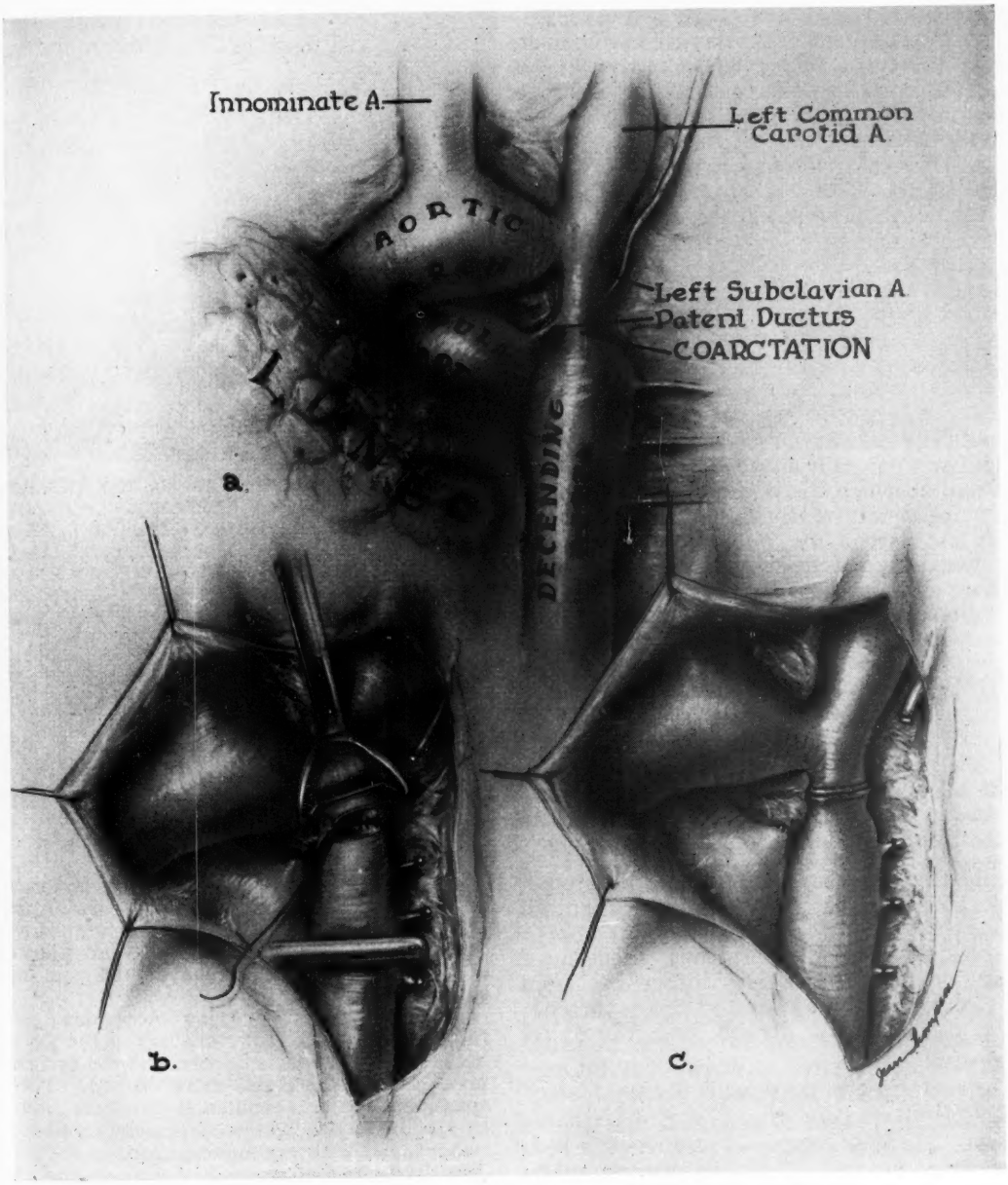

FIG. 533.—Showing the steps in the operation.

from the midline and the right epigastric superficial branch was also visible. On June 12, 1949, both posterior tibial arteries were felt and the right dorsalis pedis vessel had become palpable for the first time, but at that date the left dorsalis pedis remained undetectable. The blood-pressure, five months after the operation, in the right arm was 146/82 mm., in the left arm 126/100 mm., and in the right tibial vessels, as ascertained by palpation of the dorsalis pedis artery, 82 systolic. On screening the heart the left ventricle was still prominent, but cleared the spine in the left anterior oblique position. The aortic knuckle was placed very high in the chest, as seen in the right semi-oblique position. In the anteroposterior view the aorta barely cleared the left spinal border. It would, therefore, appear that the result of the operation had been to improve very definitely the circulation through the aorta, for the systolic pressure of the right arm has been reduced, the collateral circulation has nearly disappeared, and the arterial supply to the right foot is clearly better.

A further point worthy of note is that previous to operation a definite diastolic murmur was audible to the left of the sternum, and this was in 1945 taken to indicate an aortic valve incompetence. When a patent ductus arteriosus was found at operation, this murmur was naturally ascribed to this. Following operation, at which the distal end of the patent ductus arteriosus was removed, together with the coarctation and part of the vestigial left subclavian artery, it was assumed that the diastolic murmur would disappear. In fact, the murmur has remained and still has the high-pitched quality characteristic of aortic regurgitation. This introduces a complication from the medical point of view, and it is conceivable that the explanation is to be found in the fact that the present case may be an example of coarctation of the aorta combined with a minor degree of subaortic stenosis and aortic insufficiency, a triad of abnormalities which is well recognized. A further point in favour of this is the persistence of the systolic apical murmur conducted to the aortic base.

CONCLUSIONS

A case of coarctation of the aorta with great difference between the blood-pressures of the arm is recorded. This difference was due to a vestigial condition of the left subclavian artery. A successful anastomosis was performed between the proximal and distal ends of the aorta after excision of the coarctation.

Five months later the patient was in normal, active health, with an improving circulation to the lower limbs, and the abnormal psychological behaviour present before the operation appeared to have improved.

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HERNIATION OF THE GALL-BLADDER THROUGH THE FORAMEN OF WINSLOW

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HERNIA into the lesser sac of peritoneum through the epiploic foramen of Winslow is well known (Silverstone, 1939; Edwards and Stewart, 1943), but the gall-bladder as the herniating viscus must be a great rarity. Indeed, the author has been unable to trace a previous record of this occurrence and hence considers the present case worthy of publication.

CASE REPORT

HISTORY.—Mrs. S., aged 68 years, was first seen on Nov. 2, 1949. She gave a history of recurrent attacks of very severe epigastric pain. The first of these attacks had occurred six weeks previously and lasted for a day, being succeeded by a " niggling " pain in the same region. During the week preceding her admission to hospital she had had two further attacks, the second accompanied by vomiting. After the last attack the pain had only gradually subsided. The bowels had been normal. The only point of interest in her past history was that seventeen years previously a diagnosis of gall-stones had been made, though not proved, in view of attacks of abdominal pain and vomiting about that period. She had undergone two operations for prolapse and also suffered from rheumatoid arthritis.

ON EXAMINATION.—Palpation of the abdomen revealed an ill-defined, slightly tender, ovoid mass in the left side of the epigastrium. There was slight muscle guarding on both sides of the epigastrium. A provisional diagnosis of subacute pancreatitis was made, the mass being rather suggestive of an enlarged pancreas.

PROGRESS.—Next morning the patient seemed still further improved. However, later in the day the severe upper abdominal pain recurred and the ovoid abdominal mass became larger and more defined. The pain was spasmodic and on auscultation (for some reason difficult to explain in the light of the operative findings) intermittent loud borborygmi were heard in the same region. The diagnosis was changed in view of these findings to intussusception of the transverse colon, probably initiated by a tumour, and immediate operation decided upon.

AT OPERATION.—Under general anæsthetic by Dr. Colin Tudor, a left-sided rectus-splitting incision was made in the epigastrium. This immediately revealed a tense cystic mass approximately 4 in. in diameter occupying the lesser sac (*Fig.* 534), and the operator's first thought was that his original diagnosis had been near the truth and that the mass was a pancreatic pseudocyst. However, on retracting the parietes to the right, the edge of the right lobe of the liver was seen drawn in a puckered fashion towards the foramen of Winslow

(*Fig.* 535), and it became evident that the cystic mass was in fact the greatly distended gall-bladder occupying the lesser sac (*Fig.* 536).

The lesser omentum was broken through and a finger swept cautiously around the gall-bladder to free its flimsy fibrinous adhesions to the stomach, pancreas, and liver, particular care being exercised at the neck, which lay between the portal vein in front and inferior vena cava behind. The turbid, watery contents of the gall-bladder were aspirated and the viscus was then quite easily reduced back via the foramen to its normal position. Cholecystectomy was carried out in the routine fashion. Drains were inserted to Rutherford Morison's pouch and to the region of the lesser sac, and the wound closed.

The patient made a good recovery from the operation.

THE SPECIMEN.—The gall-bladder on examination was found to be approximately 4 in. in diameter. The wall was greatly thickened, the mucous membrane being gangrenous. It contained three calculi, each about ½ in. in diameter. There was no mesentery to the organ. The neck and part of the body were closely applied to the liver, but the fundus, being enlarged, projected well beyond the liver edge, this giving much the same pendulous appearance as a gall-bladder with a long mesentery.

Comment.—The appearance of the gall-bladder suggested that a mucocele had been present for some long period, certainly longer that the duration of the present acute symptoms (six weeks). It is difficult to surmise when the gall-bladder herniated through the foramen of Winslow, or what caused it to do so. Possibly this event caused the initial attack of severe pain, the succeeding attacks being due to episodes of partial strangulation with gradually increasing volume of the contents. Recent herniation is supported by the fact that the adhesions around the viscus were, as mentioned above, of a flimsy, fibrinous nature and the gall-bladder was very readily separated from its strange bed.

The usual content of this form of internal hernia is a portion of the small intestine, and it is surmised that in these cases the bowel enters the foramen of Winslow during a movement of flexion of the trunk. In the present instance it can readily be understood that the fundus of the hydropic gall-bladder might have become engaged in the foramen of Winslow in such an attitude of flexion. Once the fundus had passed the foramen, the rest of the gall-bladder would quickly follow since the diameter of the organ decreased from the fundus proximally. To speculate further would be unprofitable.

FIG. 534.—Photograph showing cystic mass lying above the stomach.

FIG. 535.—Photograph after retraction of parietes to show liver edge drawn towards foramen of Winslow. Pyloric end of stomach is seen crossing lower angle of wound.

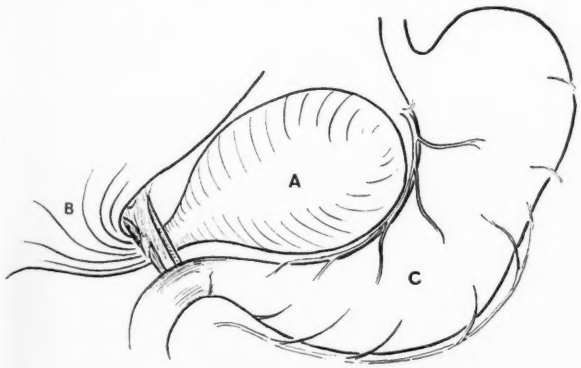

FIG. 536.—Semidiagrammatic representation of operative findings. A, Gall-bladder; B, Liver edge drawn towards foramen of Winslow; C, Stomach. The gall-bladder (A) was obscured by the gastrohepatic omentum, not shown here.

I wish to thank my house surgeon, Mr. Griffiths Rockwood, for his skilful photography.

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GASTRODUODENAL INTUSSUSCEPTION CAUSED BY A LARGE LEIOMYOMA OF THE STOMACH

By J. ELGOOD, Newport (Mon.)

While leiomyoma of the stomach is by no means an uncommon condition, the following case appears to present sufficiently unusual features to warrant its publication.

CASE REPORT

History.—Mrs. F. C., 59 years of age, attended complaining of vomiting, abdominal discomfort, and loss of weight. She stated that in 1940 she had had a hæmatemesis. Apparently she ignored this, and no confirmation or otherwise can be obtained. She remained very well until April, 1948, when she had severe melæna. This was treated energetically by her medical attendant, she recovered, and was well until September, 1948, when she started to have attacks of vomiting preceded by about two hours by severe abdominal pain. She had one or two attacks of pain and vomiting in one day, at intervals of about a week. In addition she suffered from a feeling of fullness, poor appetite, especially for breakfast, and started to lose weight rapidly.

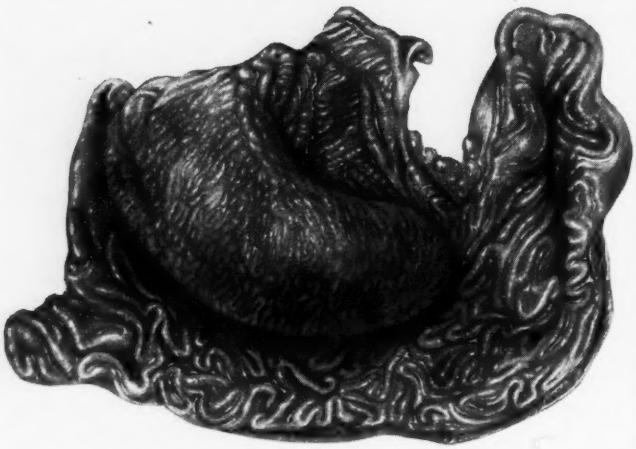

Fig. 537.—Drawing showing tumour in situ, the posterior wall of the stomach having been removed.

On Examination.—She was a thin woman with a somewhat scaphoid abdomen. No glands were palpable in the left supraclavicular triangle. The abdomen moved freely on respiration. No tenderness or rigidity was present, and no tumour could be felt, though on a previous occasion a colleague (Dr. P. E. Dipple) thought that a tumour could be felt in the epigastrium. The liver was palpable, its lower edge being felt about a finger-breadth below the costal margin, but its edge was smooth, and the impression was that it was ptosed rather than enlarged. A barium meal was done.

Radiologist's Report (Dr. W. H. Hastings).—"No evidence of œsophageal varices. There is a very extensive filling defect of the stomach, pointing to the presence of a new growth of the anterior wall projecting into the lumen, of a fungating type. There was a small gastric residue at 5 hours."

In view of this report, taken in conjunction with the age of the patient, her history, and her appearance, a provisional diagnosis of carcinoma ventriculi was made, and a laparotomy decided upon.

At Operation.—Under endotracheal gas, oxygen, and ether anæsthesia, the abdomen was opened through a high, left paramedian incision. The first part of the duodenum was at once seen to be grossly distended by a large, smooth, firm tumour. On very gentle digital pressure from the distal end this tumour was easily reduced into the stomach with a very characteristic jerk as it disengaged itself from the pyloric sphincter which had gripped it. In order precisely to determine the nature of the tumour, the stomach was opened on its anterior aspect. This revealed the tumour to be a pear-shaped mass about 3 in. long by about 1 in. in diameter, smooth, and covered with gastric mucosa. It was lying free in the gastric cavity, attached to the anterior wall of the stomach near the lesser curve at about the junction of the upper and middle thirds. On the fundus of the tumour were multiple small erosions, and at the base, in the angle between the pedicle, which was short and narrow, and the stomach wall, was a shallow, crateriform, clearly traumatic ulcer. There was no extragastric extension, but a well-marked leash of vessels was present in the lesser omentum leading to the point on the external surface of the stomach corresponding to the point of attachment of the pedicle. The tumour was extremely mobile, falling back into the fundus of the stomach as soon as that organ was lifted up.

Owing to the wide ulceration at the base of the tumour, it was considered wisest to treat the condition by means of a partial gastrectomy, rather than by means of local excision. Accordingly, an ordinary antecolic, antiperistaltic gastrectomy with a Hofmeister valve was performed. Owing to lack of adhesions, or of extra-gastric

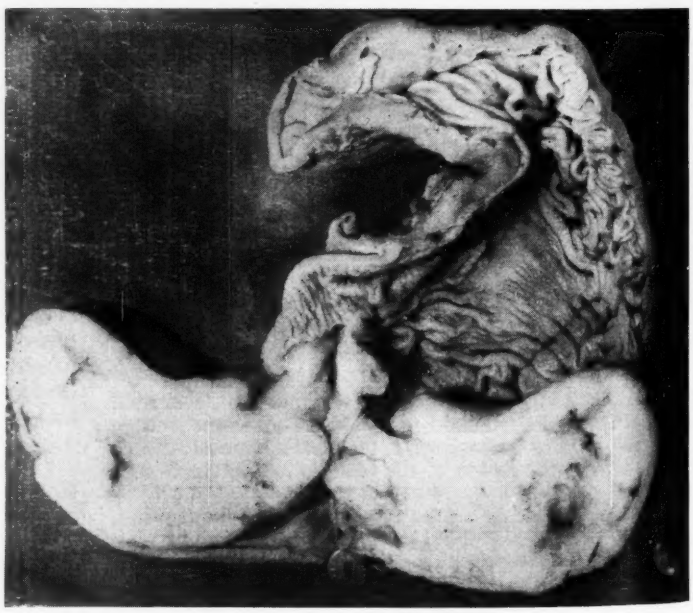

Fig. 538.—Photograph showing the tumour bisected longitudinally and turned upwards to demonstrate its structure and pedicle.

extension of the tumour, this was very straightforward, and no difficulty was experienced in placing the line of section above the tumour attachment and through healthy tissue.

Subsequent progress was uneventful, and the patient returned home in approximately three weeks, and up to the present date, nine months after operation, has remained well.

Pathological Report (Dr. J. Fine).—" The body of the stomach is filled by a polypoid growth measuring 3½ in. long by 1½ in. anteroposteriorly and 2 in. in its vertical thickness. It is covered throughout by gastric mucosa, which at the base is continuous with that of the stomach.

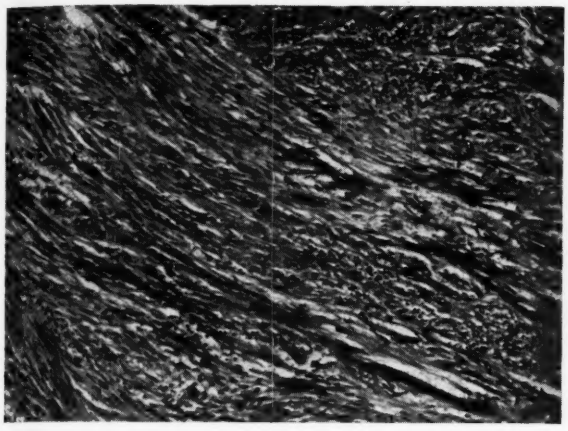

FIG. 539.—Microphotograph of tumour. (× 270.)

A traumatic ulcer is present at the base of the growth where its covering mucosa is reflected on to the stomach. This ulcer is irregular in outline, measures about ¾ in. in diameter, and has a flat, smooth floor, free from granulation tissue and consisting of submucous areolar tissue. Its traumatic nature is inferred from its physical characters and from its site at the hinge of the growth, i.e., its point of maximum mobility. (*Fig.* 537.)

" The consistence of the growth is firm and the cut surface shows it to consist of pale, faintly lobulated tissue with a whorl-like structure similar to a uterine fibroid. A few areas of hæmorrhage are present. (*Fig.* 538.)

" The growth has no distinct capsule, being limited throughout by an areolar submucous coat, from which it can be readily shelled in some places, but to which it is firmly adherent in others. It shows no continuity with the muscle coat of the stomach, though at its base is a short layer of muscle tissue from which it is sharply demarcated. Histologically the growth consists of unstriped muscle-fibres arranged in intersecting bands presenting the typical appearance of a simple leiomyoma." (*Fig.* 539.)

COMMENTS

Certain points of interest present themselves in this case :—

1. The visual evidence of the tumour slipping into the duodenum and being gripped by the pylorus.

This is well-recognized as occurring (Muir, 1943), but the evidence is usually inferential. This form of intussusception was very well demonstrated at operation, and showed clearly what the sequence of events had been—namely, colic due to the acute pyloric obstruction, followed by obstructive vomiting, then relief as the tumour was released, only to be followed by a repetition of the cycle at a later date.

2. The lack of hæmorrhage as an urgent feature leading to immediate operation.

Golden and Stout (1941) state that hæmorrhage occurs in over 50 per cent of cases, and Behrend (1944), in a series of 39 cases of gastric leiomyomata, gives as the cause of the patient coming for operation, hæmorrhage in 29 cases, dyspepsia in 8, and obstruction in 1.

3. In practically all the described cases in which hæmorrhage is the dominating factor, ulceration, frequently extensive, is present on the fundus of the tumour. (Levy and Horn, 1941 ; Whyte, 1940 ; Sworn and Cooper, 1938.) In this case, however, the ulceration was beneath the tumour, at its base, and clearly secondary to the repeated small traumata consequent on the mobility of the tumour on its pedicle.

4. The extreme mobility of the tumour. As noted at operation, when the stomach was turned back for ligation of the left gastric artery, the tumour completely disappeared, falling directly backwards through 180° to take up a position in the fundus. This mobility probably accounted for the fact that the tumour was not palpable at an earlier examination, the patient lying on her back and the tumour then being in the fundus. Had she been seen in one of her attacks of pain, it would almost certainly have been palpable.

SUMMARY

A case of a large leiomyoma of the stomach is described in a woman of 59, giving rise to gastro-duodenal intussusception.

Certain unusual features of the case are enumerated and discussed.

The condition was successfully treated by gastrectomy.

I should like to express my thanks to my colleagues, Dr. W. H. Hastings and Dr. J. Fine, for the radiological and pathological reports respectively ; to Mr. N. D. Constantine for the photographs, and to Miss C. McLarty for the drawing of the tumour.

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A CASE OF ACUTE CHOLECYSTITIS AND OBSTRUCTION DUE TO A PEDUNCULATED PAPILLOMA, IDENTICAL WITH AN ATTACK OF ACUTE CHOLECYSTITIS AND GALL-STONES

By N. M. LUND and C. E. L. BURMAN, Maritzburg, S. Africa

Rare types of surgical cases are a means of stimulating and revising our study of the physiology, anatomy, and pathology of the organ or organs involved, because, before we can decide that they are really rare, the literature must be fully explored (a tremendous undertaking to-day for the general practitioner). On the other hand, so many rare cases are either never published or are quoted in papers, lectures, periodicals, etc., which often never reach those who are responsible for abstracts of current literature, that they remain known only to a few.

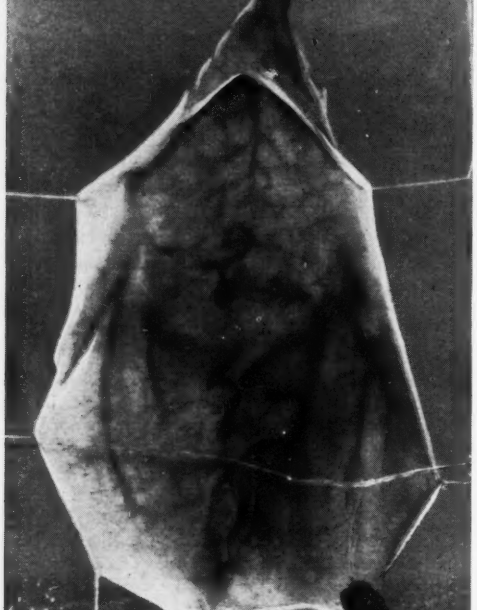

Fig. 540.—Photograph of the specimen of the gall-bladder after preparation. The wire was used to keep the pedicle of the tumour away from the gall-bladder and make the pedicle more prominent. The congestion of the vessels, the loosely folded mucous membrane, and the long pedicle with the mulberry-like tumour are well shown.

We believe that this case is of sufficient rarity to warrant record, although the literature at our disposal is not extensive, but has been scrutinized carefully.

CASE REPORT

History.—A native female, aged 40 years, was admitted to Grey's Hospital, Pietermaritzburg, on Sept. 14, 1949, with an acute pain under the right costal margin. She stated that she had lived on a European diet for some years, and had enjoyed good health until a week before admission, when she commenced to lose her appetite and felt nauseous. At 9 a.m. on the day of admission, she was suddenly seized with acute pain of an agonizing character under the right costal margin, which made her roll about the bed. The pain, with exacerbations, radiated around to the back, up into the right shoulder, and down into the right side of her abdomen. She did not vomit. Since admission, the intensity of the pain had lessened somewhat.

On Examination.—The patient was rather stout and heavily built. She lay on her right side, which she stated was the most comfortable position for ameliorating the pain. Marked tenderness was present, but no rigidity or tumour over the gall-bladder area could be felt. Murphy's sign, positive. There was some guarding in the right iliac fossa, which could be diminished by gentle palpation. The remainder of the abdominal examination was negative.

Fig. 541.—Section of tumour. The line on the right of the section between one and two o'clock on the photograph is an artefact. The darker central area shows the greater blood extravasation. (×21.)

General Examination.—No evidence of jaundice or anæmia. Tongue moist and slightly furred. Pulse 88. Temperature 99·6° F. B.P. 140/90. P.R. and P.V. revealed tenderness in the right fornix. All other systems N.A.D.

Investigations.—Visualization of the gall-bladder was carried out and the report of the radiologist was: "The appearances are compatible with the presence of a translucent biliary calculus (?). Gall-bladder function appears normal."

Diagnosis.—The history was typical of gall-stones and acute mild cholecystitis. The fact that she was

seedy and off-colour for a week strongly suggested a preliminary cholecystitis, and the report of the radiologist that the appearances were compatible with the presence of a calculus made the diagnosis of an acute cholecystitis associated with gall-stones clinically a sound and practical deduction.

TREATMENT.—Cholecystectomy was carried out by one of us (N. M. L.), who noticed that there was no undue mobility of the gall-bladder, but that the fundus was completely covered by peritoneum to the extent of ½ in. or more. Examination of the appendix and pelvic organs revealed them to be quite normal.

Macroscopical examination of the gall-bladder, after removal, showed a more or less normal gall-bladder, except for somewhat marked congestion of the blood-vessels on the surface, and a small mass felt on palpation. On opening up the gall-bladder the small mass was found to be a papilloma; it had the exact appearance of a small mulberry and was attached by a thin pedicle, nearly 1 in. long, to the fundus of the gall-bladder.

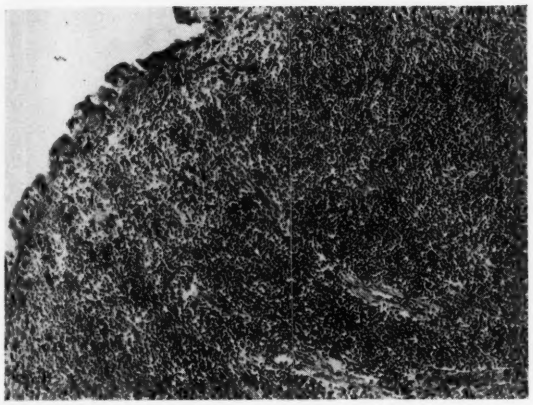

FIG. 542.—High-power microphotograph showing single layer of columnar epithelium and vascular connective tissue with blood extravasation. (×80.)

There also appeared to be loose-folded pouching in the fundus, which became more evident after the preparation of the specimen. These clinical observations are fairly well shown in the photograph (*Fig.* 540).

A small portion was removed for microscopical examination and the pathologist reported as follows: "This piece of the papilloma consists of a vascular connective tissue into which there has been hæmorrhage. The surface is partly covered by a single layer of columnar epithelium, but over much of the surface the epithelium has been lost. There is no evidence of malignancy." (*Figs.* 541, 542.)

COMMENT

Two possibilities present themselves clinically in the causation of the attack of acute cholecystitis and obstruction: (1) Torsion; (2) Attempted passage of the polyp.

1. Torsion.—It is well recognized that any tumour or organ, before a twist can occur, must have a pedicle, must have space to turn in, and a shape which will allow of rotation. The longer the pedicle, the more chances there are of several twists occurring before marked interference of the circulation takes place. In some cases of torsion of ovarian cysts we have seen as many as four to six twists present before the effects of torsion became evident, i.e., the pedicle has been so much shortened by the number of twists that it is only the last one that causes the mischief by its increased constriction. In those cases with a short pedicle, one twist is often

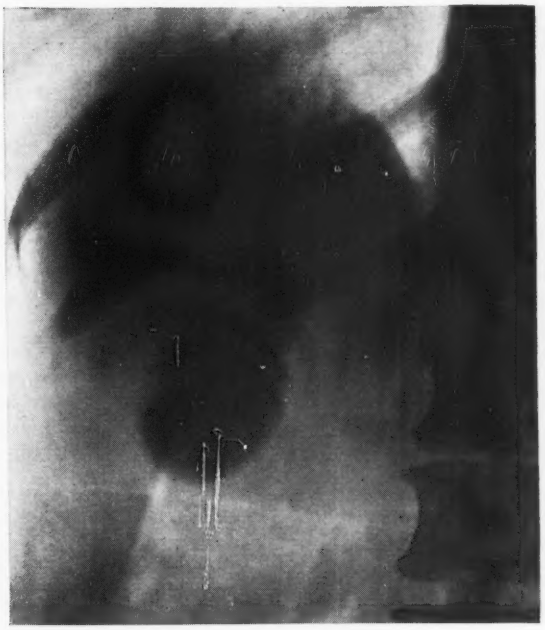

FIG. 543.—Gall-bladder full, with the translucent area evident but not so well marked as in *Fig.* 544.

sufficient to cause mischief and interference with the blood-supply.

All the required conditions were present in this case, and on first thoughts the report of the pathologist would appear to support this theory, but the

FIG. 544.—Gall-bladder contracted but not quite empty. The translucent area is evident at the fundus.

appearances of the tumour, the absence of any sign of torsion of the pedicle, the marked congestion and enlargement of the vessels, and the fact

that the mucous membrane of the gall-bladder is insensitive, and especially so the polyp, rule out this theory.

2. Obstruction of Hartman's Pouch or the Cystic Duct by the Tumour.—This would appear to be the most likely explanation. The pain had completely passed off before visualization of the gall-bladder was carried out and the transparent shadow appears in the area of the fundus, suggesting release of the tumour from either Hartman's pouch or the cystic duct. The marked congestion of the blood-vessels, the long pedicle of the papilloma, with absence of any signs of congestion or torsion in the pedicle, and the loosely folded pouching in the fundus (evident in the photograph, *Fig.* 540, and more so in the radiographs, *Figs.* 543, 544) is noteworthy. It is also conceivable that the body of the gall-bladder might have gripped the polyp and produced an obstruction in its length before the polyp reached Hartman's pouch or the cystic duct, but this seems less likely than the other occurrence.

Analogous conditions are so often seen elsewhere in the human body that this case closely resembles a papilloma of the rectum with a long pedicle being extruded and nipped by the anal sphincter; or a polyp of the uterus with a long pedicle being extruded and nipped by the external os; or again, an intestinal polyp being gripped by the gut, causing an intussusception. Some degree of inversion of the gall-bladder must have been present for the tumour to have reached Hartman's pouch or cystic duct, and this is suggested by the marked congestion and prominence of the vessels in the area of the fundus from which the pedicle of the papilloma takes origin and the loose-folded pouching of the fundus.

The absence of malignancy and the somewhat long pedicle with a mulberry type of tumour are noteworthy clinical data of this interesting case.

Our thanks are due to Dr. Cowie for the pathological report; Dr. Borrowdale for the X-ray report; and Dr. Stuart for the notes.

A CASE OF REDUPLICATION OF THE TRANSVERSE COLON

By T. TWISTINGTON HIGGINS

SURGEON, HOSPITAL FOR SICK CHILDREN, GREAT ORMOND STREET, LONDON

Ladd and Gross (1941) give three characteristics common to all duplications of the alimentary tract:—

"1. Each is contiguous with and strongly adherent to some part of the alimentary tract.

"2. Each has a smooth muscle coat, usually in two layers.

"3. Each is lined with a mucosa or epithelium similar to some part of the stomach, intestine, or colon."

Closed cysts exhibiting these characteristics are not infrequent in relation to the small intestine, where they are usually classified as the 'enterogenous' types of mesenteric cyst. The intimate relation to the bowel often determines intestinal obstruction and removal almost invariably necessitates resection of bowel.

Such cysts occur more rarely at other sites along the alimentary canal from tongue to rectum. Ladd and Gross record 18 cases with the following incidence:—

Base of tongue	1	Jejunum	2
Œsophagus	3	Ileum	7
Stomach	1	Cæcum	1
Duodenum	1	Sigmoid	1
	Rectum 1		

Communication with the bowel is, however, rare. It was present in 2 only of Ladd and Gross's cases. In the instance here recorded the proximal segment of the transverse colon was involved and there was a lengthy and free ostium which permitted partial emptying of the diverticulum into the colon. The resemblance of the duplication in this case to the normal condition seen in some animals, notably the rabbit, was striking, and would seem further to substantiate the views of Lewis and Thyng (1907) as to the origin of these anomalies.

CASE REPORT

S. J., aged 5 years. Referred by Dr. W. G. Wyllie. Complaint: Abdominal distension, intractable constipation, and failure to thrive.

History.—Breast-fed to nine months. The child had been constipated from birth. The bowels had never opened more frequently than every four to five days. The motions, though of average size, were only passed with great straining. There had always been much noisy passing of foul wind. The severe abdominal distension had been associated with loud borborygmi and much

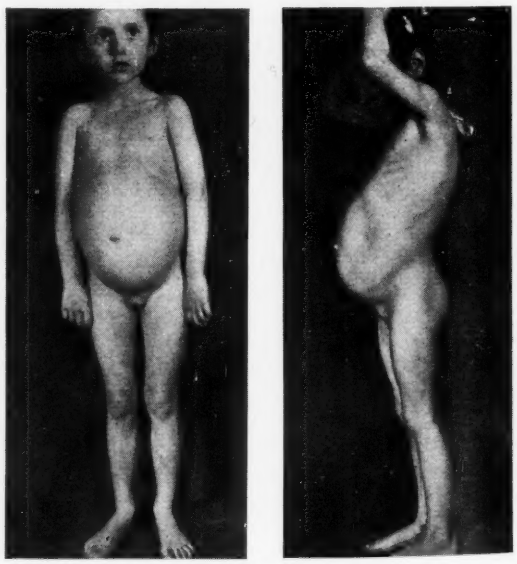

Fig. 545.—Showing abdominal distension.

pain, and the child and her mother had both observed the peristaltic movements.

The general health had always been poor.

FIGS. 546, 547.—Barium enema, demonstrating sac with fluid level and gas.

Family History.—Two previous children in the family had died in infancy from "gastro-enteritis". Careful inquiry, however, established the fact that in neither case was any congenital malformation responsible.

FIG. 548.—The appearance after partial evacuation.

ON EXAMINATION (March 4, 1949).—The general appearance is well seen in the photograph (*Fig.* 545). The child weighed 37 lb. The skin was sallow and pigmented and the breath foul.

The abdominal distension was severe, the ribs splayed, and the umbilicus everted. From time to time gross peristaltic waves were visible and the tympanites was drum-like in quality. The rectum was empty of fæces but distended with gas.

Radiography.—This was remarkable. The outstanding feature, as will be seen from the photographs (*Figs.* 546–548), was that of a huge sac in the upper left abdomen showing a fluid level surmounted by a gas

FIG. 549.—Condition at operation.

collection. This led us to believe that some form of reduplication was present, and it was on this supposition that laparotomy proceeded.

AT OPERATION (March 9).—On opening the abdomen, the condition as seen in *Fig.* 549 was revealed. The ballooned blind sac of the diverticulum filled the upper left abdomen, compressing the stomach and thrusting up the diaphragm, and was covered by remnants of the transverse mesocolon. The narrower 'stalk' reduplicated the transverse colon and in its proximal segment had a common lumen. The muscular coats were clearly conjoint and the vascular supply quite inseparable.

FIG. 550.—Specimen after removal.

It was clear that resection was the only feasible procedure.

The sac was gently dissected from its bed, which, though tedious, did not prove unduly difficult. The whole was then resected from a point just distal to the hepatic flexure to one just short of the splenic flexure. The re-anastamosis was planned obliquely and it was not necessary to mobilize the splenic flexure. The specimen is shown in *Fig.* 550.

The child made an uninterrupted recovery and has made entirely satisfactory progress since the operation. Bowel actions are normal.

The photograph (*Fig.* 551) shows her nine months after the operation (weight 47 lb. 8 oz.).

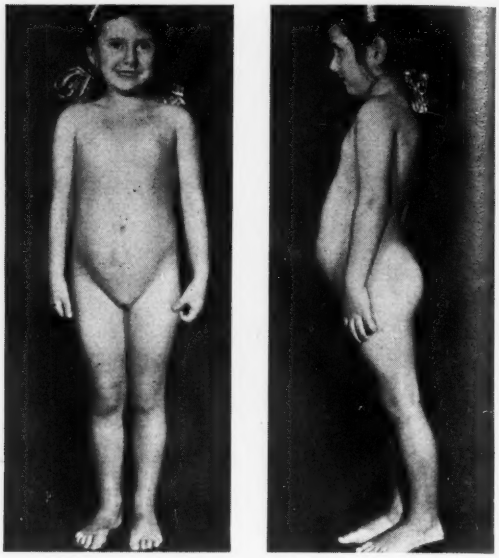

FIG. 551.—Patient nine months after operation.

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MESENTERIC LIPOSARCOMA

A RARE CAUSE OF INTESTINAL OBSTRUCTION

BY JOHN M. S. MANSON

LIPOSARCOMA is a sufficiently rare lesion to warrant its recording. The majority have been found arising in the retroperitoneal and omental regions, but no report has been found of this rare tumour causing intestinal obstruction. The following case, seen at St. James's Hospital, S.W., provided an interesting problem in diagnosis.

CASE REPORT

Mrs. A. K., aged 60, was admitted on Oct. 16, 1949, complaining of occasional vomiting and progressive abdominal distension of three weeks' duration. For four months prior to admission she had had colicky, central abdominal pain which had been increasing in severity, and she had lost approximately 2 st. in weight. No blood or mucus had been observed in the stools. In 1932 she had had an operation in Germany, at which were performed cholecystectomy for gall-stones, hysterectomy for "hæmorrhage", and appendicectomy. She stated that her mother, four sisters, and one brother had all died between 50 and 60 of "cancer of the stomach".

ON EXAMINATION.—There was evidence of loss of weight (weight 6 st. 2 lb.), but the patient's general

health was good. At intervals of about five minutes she had mild attacks of colic associated with marked visible peristalsis (*Fig.* 552) passing from left to right across the lower abdomen and disappearing with audible borborygmi. No ascites was present and no mass could be felt in the abdomen. Succussion splashing was present and gastric

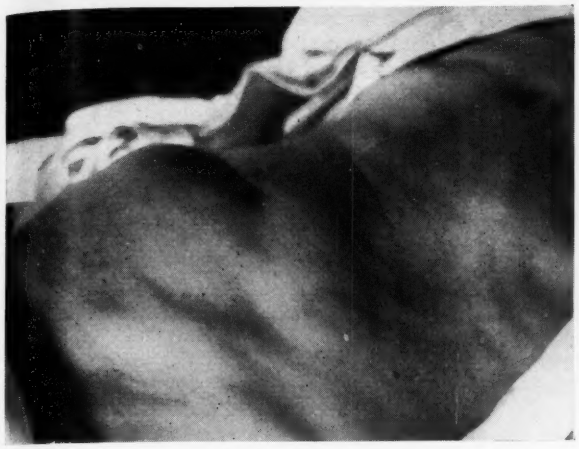

FIG. 552.—Abdomen showing visible peristalsis and original operation scar.

aspiration produced 8 oz. of normal fluid but did not affect either the degree of visible peristalsis or the splashing. X-ray examination of the abdomen showed dilatation of the small bowel with numerous fluid levels (*Figs.* 553, 554).

AT OPERATION (Mr. N. C. Tanner).—On Oct. 21 laparotomy was performed through the lower part of the old incision scar. The distal ileum was found bound down by dense adhesions to the right lateral pelvic wall;

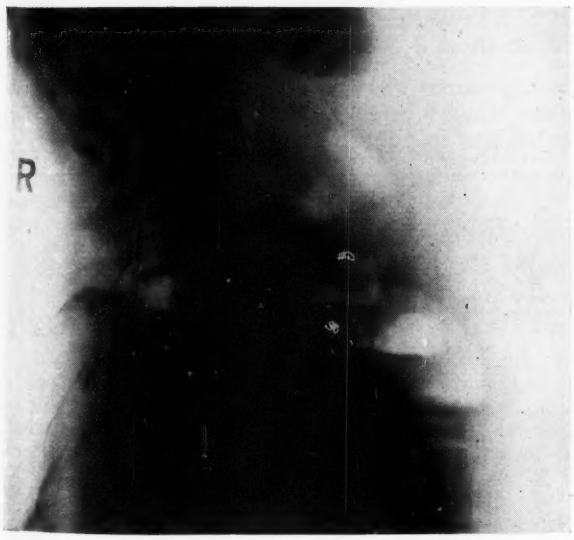

FIG. 554.—Lateral film of abdomen.

these were divided, thus allowing the ileum to be delivered through the wound. At the point of attachment of the adhesions almost complete atresia of the bowel lumen was present, and in the adjacent mesentery large, firm, 'grape-like' swellings were present, two being juxta-ileal and several being at the root of the mesentery. One of them was removed for biopsy and a side-to-side anastomosis was performed above and below the stricture.

Recovery was uneventful and the patient was discharged to a convalescent home on Nov. 1.

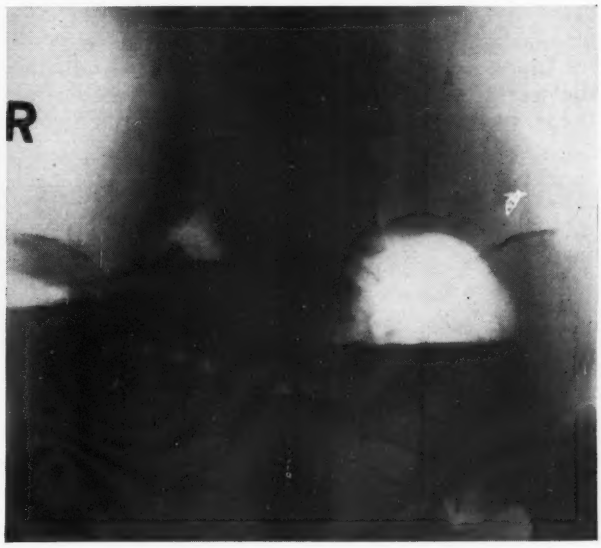

FIG. 553.—Plain film of abdomen showing fluid levels.

The histological report on the mesenteric tumour was: "Well-differentiated myxoid type of liposarcoma" (*Figs.* 555, 556) and the patient was therefore readmitted.

X-ray examination of the patient's chest excluded a mediastinal tumour and careful search did not reveal the presence of either subcutaneous or intramuscular fatty tumours.

SECOND OPERATION (Mr. N. C. Tanner).—On Dec. 6 the previous lower abdominal incision scar was excised

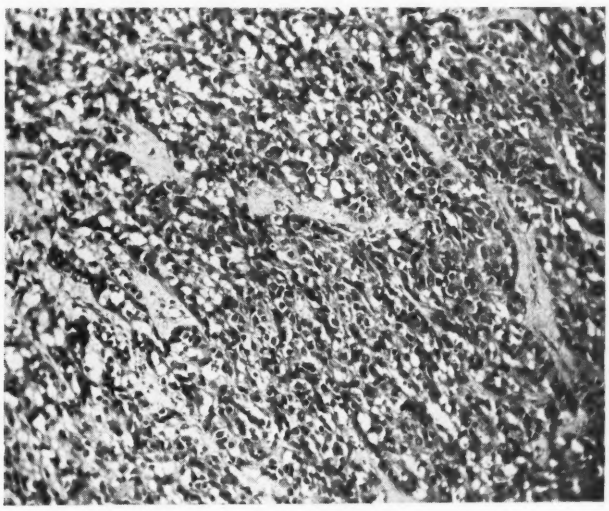

FIG. 555.—Microscopical appearances. (×75.)

and on opening the abdomen the anastomosis was found to be working satisfactorily. Marked enlargement of the masses in the mesentery had occurred since the previous laparotomy and other small masses had appeared (*Fig.* 557). No secondary masses were found elsewhere in the abdomen. Resection of the affected loop of ileum and an end-to-end ileo-ileostomy were performed.

Recovery was rapid and without incident and on Dec. 16 the patient was again discharged to a convalescent home. By Dec. 30 her weight had increased to 8 st. 2 lb.

DISCUSSION

Liposarcomas have been reported from all over the world except the Asiatic continent; they affect the sexes equally, and, although they most commonly develop in later life, they may occur at any age. Schiller (1918) states that they may arise from pre-existing lipomas, and Haagensen and Krehbiel (1936) were able to produce them experimentally by subcutaneous injections of benzpyrene. Multiplicity is a common feature of liposarcomas, and one has to determine whether these are independent or metastatic. The commonest sites of metastases are lungs, liver, and bone-marrow.

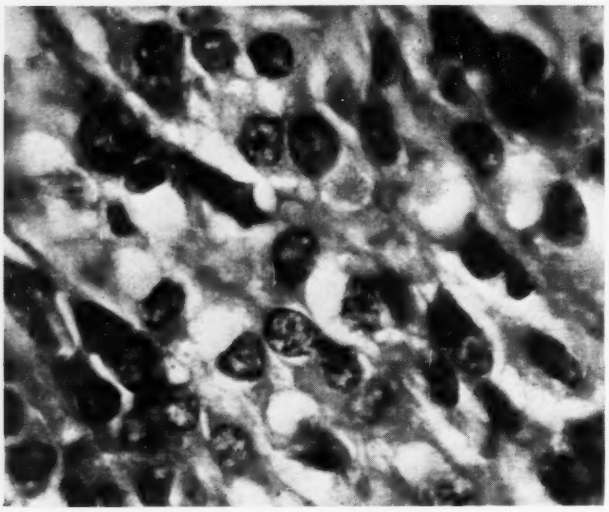

FIG. 556.—Microscopical appearances. (×675.)

Ewing (1935) separates liposarcomas into two main types—one, the myxoliposarcoma; and the other, the granular-cell lipoblastoma; Stout (1944) recognizes four classes: (1) The well-differentiated myxoid type which may become enormous but does not metastasize. (2) The poorly differentiated myxoid type in which the lipoblasts are bizarre. This type is often difficult to eradicate and may metastasize. (3) The round-celled or adenoid type, which is also difficult to eradicate and which may metastasize. (4) The mixed type which consists of two or more elements of the preceding classes and which is definitely malignant.

Stout's classification of liposarcomas is particularly attractive to surgeons because it provides a satisfactory guide to treatment and prognosis.

The findings at operation and the absence of demonstrable metastases force the author to conclude that this tumour belongs to the first group and that the prognosis is excellent.

FIG. 557.—Resected loop of ileum with fibrous stricture (arrow), side-to-side anastomosis, and tumour mass in mesentery.

SUMMARY

1. A case is reported of intestinal obstruction due to mesenteric liposarcoma.

2. The features of this rare tumour are described, and on these is based the prognosis.

My thanks are due to Mr. Norman C. Tanner, under whose care the patient was admitted, for permission to publish this case.

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REVIEWS AND NOTICES OF BOOKS

Coagulation, Thrombosis, and Dicumarol. By SHEPARD SHAPIRO, M.D.; and MURRAY WEINER, B.S., M.S., M.D. Pp. 131. New York: Brooklyn Medical Press. $5.50.

THIS monograph on thrombosis and anticoagulants has been written by two experts in the subject and gives a sound and comprehensive review of the whole matter. Starting with the physiology of the clotting of blood, the authors proceed to describe in detail the process of hæmostasis in the body and the diseases in which thrombosis is the essential feature. A chapter follows on the treatment of these diseases with anticoagulants, and although a brief but fairly complete summary is given of the mode of action and use of heparin, the whole of the rest of the volume is devoted to dicumarol. Starting with its discovery and development, the authors proceed to describe its effects upon prothrombin activity in man, its toxicity, and the appropriate antidotes. Full accounts are then given of the indications and contra-indications for its use and the clinico-pathological methods required for controlling dosage and observing the results of dicumarol therapy.

There is a valuable appendix which gives full details of the technique of the various tests and estimations which are required, and the volume is completed with a comprehensive bibliography. This book is recommended to all clinicians who are seeking for information about how to use dicumarol and how to avoid the dangers which are the inevitable consequences of its misuse.

Care of the Surgical Patient. Including Pathologic Physiology and Principles of Diagnosis and Treatment. By JACOB FINE, M.D., Surgeon-in-Chief, Beth Israel Hospital; Professor of Surgery at Beth Israel Hospital, Harvard Medical School. $6\frac{3}{8} \times 9\frac{5}{8}$ in. Pp. 541 + xvi, with 40 illustrations. 1949. Philadelphia and London: W. B. Saunders Co. 40s.

THE author says of this volume in his Preface that "the book is not a text-book of surgery". It is certainly unusual in its style and arrangement, for it might almost be a synopsis of a teacher's remarks in the course of ward rounds or out-patient sessions. It makes no attempt to cover the ground systematically, and one feels that the author and his collaborators have often failed to discriminate between the very important principles and the much less important details in the management of surgical patients. Furthermore it offers a mixture of pathology, physiology, and therapy in which none of the ingredients is in sufficient amount to be satisfying to the student or of substantial assistance to the surgeon.

Though there is to be found in almost all the chapters much sound advice which is the product of ripe experience, the work is so patchy that it cannot be regarded as having established its claim to be an epitome of "the essential facts required for an intelligent understanding of surgical diseases, and the basic principles involved in their diagnosis and treatment".

The Principles of Pathology. By R. A. WILLIS, D.Sc., M.D., F.R.C.P., Professor of Pathology in the University of Leeds. $6\frac{3}{4} \times 9\frac{3}{4}$ in. Pp. 722 + xii, with 288 illustrations. 1950. London: Butterworth & Co. (Publishers) Ltd. 50s.

THIS large volume is dedicated to Professor Matthew J. Stewart, the retiring Professor of Pathology in the University of Leeds, a very fitting and appropriate tribute to a very great pathologist by his successor in office.

Those of us who have read Professor Willis's former works on tumours and their spread will welcome another book from his pen, well knowing that we shall not be disappointed with its contents.

Professor Willis, while a student some thirty years ago, decided that there was a great need for a comprehensive outline of pathology, and this idea has now come to fruition to the great benefit of medical students and practitioners.

The author has had extensive experience in pathology in Australia, the Royal College of Surgeons of England, the Royal Cancer Hospital, and now at the University of Leeds. His matured experience and his lucid style make the present volume a most valuable one. The illustrations are a great feature of the book, and many of them are original and could not be bettered.

Both undergraduates and postgraduates will thank Professor Willis for the appendixes which are to be found at the end of the volume, as they will be found most useful, especially Appendix C on observing, recording, and reading; how few medical men can describe gross pathological specimens.

We expect to find new names in pathology, but skeletogenesis is a new one to us, but no doubt it will be adopted. This volume will be as popular as it is useful.

Orthopædic Surgery. By WALTER MERCER, M.B., Ch.B., F.R.C.S.(Edin.), F.R.S.(Edin.), Professor of Orthopædic Surgery, University of Edinburgh; etc. With a Foreword by Sir JOHN FRASER, Bart., K.C.V.O. Fourth edition. $5\frac{7}{8} \times 8\frac{7}{8}$ in. Pp. 1016 + xii, with 427 illustrations. 1950. London: Edward Arnold & Co. 50s.

THE new fourth edition of this book has been awaited with interest, for the third edition published in 1944 was reprinted in 1945 and 1947 owing to the popular demand for the book. The new edition contains much new material and many new illustrations and has been very thoroughly revised; it is a most readable and practical treatise on the subject of orthopædics.

The bibliography at the end of the book is comprehensive, and very valuable to the student or surgeon who requires to gain further knowledge on any practical orthopædic problem.

This book will long remain the standard text-book on orthopædic surgery in this country.

A Synopsis of Surgical Anatomy. By ALEXANDER LEE MCGREGOR, M.Ch., F.R.C.S., Senior Surgeon, Johannesburg General Hospital, Lecturer in Surgery, University of the Witwatersrand. Seventh edition. $4\frac{3}{4} \times 7\frac{1}{4}$ in. Pp. 778 + xii, with 746 illustrations. 1950. Bristol: John Wright & Sons Ltd. 25s.

IT is only eighteen years ago that the first edition of this book appeared; since that date there have been six new editions, and some of these have been reprinted three times. These facts speak for themselves and prove the value of this very practical manual.

The author all along has been able to present anatomical facts of practical value to the student and practitioner and this is the great charm of the book. The illustrations are original to a great extent and just demonstrate the essential points and are not overburdened with too much detail.

The book still has a popular appeal to surgeons and postgraduates who are contemplating higher diplomas.

One of the best books in the Synopsis series.

Les Infiltrations du Sympathique. Physiologie, Indications, Techniques. By MAURICE LUZUY. With a Foreword by Prof. R. LERICHE. Second edition. $6\frac{1}{4} \times 9\frac{3}{4}$ in. Pp. 304 + xx, with 77 illustrations. 1950. Paris: Masson et Cie. 1200 fr.

THIS book is a re-arrangement and amplification of that by G. Arnulf on stellate ganglion injection which appeared and was reviewed in this JOURNAL in 1947. It is naturally a larger volume because the technique of and indications for lower thoracic, lumbar, and sacral infiltrations have been added, and in addition to the former illustrations there are good drawings to show the anatomy of, and injection methods in, these other regions. The work indicates the value both in clinical investigation and in therapy of blocking the sympathetic pathways in an astonishing number of lesions, ranging from the after-effects of injury and disorders of the peripheral blood-vessels to 'functional' visceral disease in the abdomen and endocrine disorders.

As in the former volume, a great deal is written about the imbalance in the vegetative nervous system which is supposed to underlie all these abnormal conditions, and which is corrected by infiltration of the sympathetic. Of the extent and the value of the author's long experience of these methods and of the accuracy of his observations we have no doubt whatsoever, and we acknowledge our indebtedness to him for placing his facts on record; but we find it difficult to harmonize certain of his views on the autonomic system with orthodox physiology. It may well be that the phenomena he describes cannot all be explained by what is at present accepted as the physiology of the autonomic system. As Professor Leriche, who has written the introduction to this book, once remarked. "If these observations cannot be wholly explained by the old physiology a new physiology must be found to explain them!" Their importance to the practising surgeon is unquestionable, and Luzuy's book provides physiologists as well as clinicians with much food for thought.

British Surgical Practice. General Editors: Sir ERNEST ROCK CARLING, F.R.C.S., F.R.C.P., Consulting Surgeon, Westminster Hospital; and Sir JAMES PATERSON ROSS, K.C.V.O., M.S., F.R.C.S., Surgeon and Director of Surgical Clinical Unit, St. Bartholomew's Hospital; etc. In eight volumes. $6\frac{3}{8} \times 8\frac{3}{4}$ in. Volume VIII. Pp. 630 + xxii, with 264 illustrations and 9 coloured plates. 1950. London: Butterworth & Co. Price per volume £3, Index £1.

THE last of the eight volumes of this magnificent work has now been published and deals with the surgery of the spleen, stomach, thymus gland, thyroid gland, uterus, and many other surgical conditions. It is well up to the standard of the other volumes and reflects the British methods of surgical practice. The section on vascular surgery by Gordon Murray is an excellent example of how such a subject should be presented and illustrated.

The eight large volumes are a credit to British surgery and the editors-in-chief may now take some rest and feel that theirs is in truth a work well done and one in which they may justly be proud.

Cleft Palate and Speech. By MURIEL E. MORLEY, B.Sc., I.C.S.T., Speech Therapist to the Royal Victoria Infirmary, The Hospital for Sick Children, and The Newcastle General Hospital, Newcastle upon Tyne. Second Edition. $4\frac{7}{8} \times 7\frac{1}{8}$ in. Pp. 160 + xx, with 56 illustrations. 1950. Edinburgh: E. & S. Livingstone Ltd. 12s. 6d.

WHEN the first edition of this book was published some five years ago it was immediately recognized as a volume which was full of valuable information. The second edition is even more valuable because it contains the matured experience of one who has devoted a vast amount of time to the study of congenital speech defects.

It is true that the surgeon who operates on cleft lip and palate deformities desires to make his patient look well, eat well, and speak well, and the last is the most important of the three.

To obtain first-class results with patients with congenital deformities of the lip and palate the surgeon must co-operate with the speech therapist, and this book is the outcome of that important co-operation.

The text is well arranged and illustrated with clear practical drawings and coloured plates. There can be little doubt that every surgeon who is interested in cleft palate problems should have this book as his guide, philosopher, and friend in the post-operative treatment of these defects.

Cranioplasty. By DAVID L. REEVES, A.B., M.D., Santa Barbara, California. *American Lecture Series No.* 39. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Pp. 119 + x, with 71 illustrations. 1950. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell Scientific Publications.) 22s. 6d.

IN this well-documented little book there is an outline of the attempts which over many years have been made to close defects in the cranial bones and the materials which have been used for the closure.

It is estimated that 5000 cranioplasties were performed by the medical services of the United States during the recent war. The commonest position for bony defects in the skulls of service men was found to be the left frontal region, and it is suggested that the reason is that the advancing soldier has his head turned slightly to the right. The indications for closure of bone defects are discussed. In a chapter on the post-convulsive state, it is interesting to note that in spite of early surgery and chemotherapy, the incidence of post-traumatic epilepsy has shown little improvement on that of the first world war. Wounds over the hemispheres that have produced dural penetration still lead to epilepsy in from 35 to 50 per cent of cases. Closure of bone defects has little if any effect on the fits. The author relates his experience with 196 cases of cranioplasty following the recent war, and also with the repair of defects resulting from the removal of bone in such conditions as eosinophilic granuloma, osteoma, meningioma, and osteomyelitis. He prefers tantalum to acrylic resin for the repair of large defects and autogenous bone or cartilage for small ones, and describes his methods of operating. This is a comprehensive little monograph on the subject.

Les Problèmes du Traitement des Ulcères perforés gastro-duodénaux. La Gastrectomie d'Urgence—Indications et Résultats. By J. MIALARET, Chirurgien des Hôpitaux de Paris, and G. EDELMANN, Chef de Clinique chirurgicale à la Faculté. $5\frac{1}{2} \times 9$ in. Pp. 136. 1949. Paris: Masson et Cie. 320 fr.

THIS treatise presents the argument, supported by personal experience, in favour of treating perforated peptic ulcer by immediate gastrectomy. A careful analysis has been made of the authors' cases and of others collected from the literature to show the influence upon the mortality-rate of the time that has elapsed since the perforation occurred, the age of the patient, the site of the ulcer, the size of the perforation, the state of the neighbouring stomach or duodenal wall, and the amount of peritoneal exudate. Their own statistics show a death-rate of 23 per cent in 189 perforations treated by simple suture, and 10 per cent in 100 treated by gastrectomy, but they admit that the two groups were not strictly comparable in regard to the various conditions mentioned above.

As a result of their experience the authors recommend immediate gastrectomy for very large or recurrent perforations, and for perforations complicated by stenosis, unhealthy surrounding tissue, and hæmorrhage. Resection is contra-indicated in late interventions, in patients over the age of 50, when the ulcer is very high in the

stomach or very low in the duodenum, and when the conditions are not ideal for major surgery. While admitting that the best thing for a drowning man is to pull him out of the water rather than to give him a swimming lesson first, they are so impressed with the late results of resection as compared with those of simple suture that they are encouraged to publish their observations, which they do with a clarity and restraint which makes their presentation all the more attractive.

Modern Surgical Technic. By MAX THOREK, M.A., LL.D., Sc.D., F.I.C.S., F.B.C.S., D.C.M., Professor of Surgery, Cook County Graduate School of Medicine; Surgeon-in-Chief, American Hospital of Chicago; etc. With a Foreword by FRED W. RANKIN. Second edition. Four volumes and Index volume. 7 × 10 in. Pp. 3170 + 85-p. Index. 2590 illustrations, including 57 colour plates. 1949. Philadelphia and London: J. B. Lippincott Co. £26.

THE second edition of this monumental work has been thoroughly revised and much new matter has been added. Much has happened in the field of surgery since the first edition was published in 1938—in fact, greater progress has been made in the decade from 1940 to 1950 than for fifty years before this period.

Taking the work as a whole there are certain constructive criticisms that can be made. Firstly, the set-up is too encyclopædic, every conceivable operation that has been done for any particular surgical condition is described. This is a pity, because it does not give the young surgeon any idea as to which is the best operation. The reader is left to his own choice and is not given the matured advice of the experienced clinical teacher. Quite half of the operations described could be called obsolete as far as British surgery is concerned. Again, the majority of the illustrations are too large and the size of the four huge volumes could be considerably reduced.

Volume I is devoted to a large extent to general operative considerations and the advice given is sound and constructive; the pre- and post-operative treatment is very comprehensive and, if anything, very vigorous and tiring to the patient. The large number of tests which are performed on the patient seem to be excessive and the surgeon should surely rely on his own clinical acumen and only order tests and examinations if the clinical manifestations require to be confirmed.

The surgery of the head and neck is also included in this first volume. The operations described for the repair of cleft palate and lip are somewhat antiquated, no mention is made of the Wardill operation, nor is there any description of the operations devised by Oldfield or Denis Browne. Mirault's operation, which is described in detail, is no longer performed in England.

Plastic surgery is given full measure and there is a tendency to overdo the various operations that have been devised for face lifting.

Volume II deals with the surgery of the nervous and vascular systems and is well written and up to date, but there must be very few neurosurgeons who would use the Jentzer trephine to-day and yet a very full description of this complicated apparatus is given and some twenty-one drawings illustrating how it is used. Operations for oxycephaly are not performed in England for they fail to benefit the patients.

The surgery of the sympathetic nervous system is well described and the technique used well illustrated.

Vascular surgery is dealt with in a comprehensive manner and the reader can follow the descriptions very well and the illustrations have been well chosen.

Surgery of the chest, also included in this second volume, is perhaps the best part of the whole work. The technique and the illustrations are excellent.

The surgery of bones and joints completes this volume, and, although practical and up to date, it is a pity that some of the radiographs are not of a better quality.

Volume III is devoted to two main subjects; the surgery of the breast and surgery of the abdomen.

Nearly one hundred pages are devoted to the surgery of the breast and much of this deals with plastic operations on the breasts. No less than twelve separate incisions are illustrated for radical mastectomy; this gives the reader the idea that almost any form of incision will prove adequate for the radical removal of the breast, and this is far from the truth.

Surgical operations of the abdomen are fully described in a very lucid style and some of the illustrations are excellent, especially those depicting Maingot's technique of splenectomy.

Volume IV contains the many and varied techniques in vogue in the treatment of herniæ. Gynæcological and genito-urinary surgery are also included in this volume.

A fifth volume is devoted to a very comprehensive index dealing with the other four volumes.

The whole work is a Herculean task and one which very few men would undertake, and Professor Thorek and his contributors are to be congratulated on the way they have covered the entire field of operative surgery.

Short Textbook of Surgery. By C. F. W. ILLINGWORTH, C.B.E., M.D., Ch.M., F.R.C.S. (Edin.), Regius Professor of Surgery, University of Glasgow. Fifth edition. 6 × 9¼ in. Pp. 676 + viii, with 233 text illustrations and 13 plates. 1950. London: J. & A. Churchill Ltd. 30s.

THE usefulness and popularity of this volume can be assessed by the fact that a fifth edition is required in just over ten years since the first edition appeared. The new edition has been completely revised and new sections have been added on pulmonary stenosis and portal hypertension, while the section on infections of the fingers and hand have for the most part been rewritten.

This so-called 'short text-book' is on the whole quite comprehensive enough for the average student to glean all that is required to pass the qualifying examination in surgery at any University.

The majority of the illustrations are good, but some are so worn that it is hoped that in the next edition new blocks will be used.

Plastic and Reconstructive Surgery. A Manual of Management. By FERRIS SMITH, M.D., F.A.C.S., Consultant in Plastic Surgery, Blodgett Memorial Hospital, Grand Rapids, Michigan. 6 × 9⅛ in. Pp. 895 + xxii, with 592 illustrations. 1950. Philadelphia and London: W. B. Saunders Co. 75s.

THE two world wars brought plastic surgery into its own and made it a surgical speciality of great importance.

This book is comprehensive in outlook for it covers the whole body as far as plastic operations are concerned; year by year the plastic surgeons take over more and more of the work which has been performed by the general surgeon in the past.

The use of the pedicle tube graft has made reconstructive surgery of the face possible and the results obtained in the treatment of bad facial burns are excellent. The two world wars, with the very numerous cases of burns, gave a great fillip to this type of grafting. It is quite true, as the author states, that haste in reconstructive surgery is made slowly, there is no short cut to the many principles of plastic surgery. With some thirty-five years of clinic experience as a background, the author has drawn on this and illustrated his text with numerous clinical cases showing the condition before and after operation. This type of presentation is of great value to the reader, for it helps him to make up his mind as to the real advantage of the treatment adopted.

This volume is really for the post-graduate and it is an excellent presentation of what plastic surgery is doing in the world to-day.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to readers.]

A Companion to Manuals of Practical Anatomy. By E. B. JAMIESON, M.D., formerly Senior Demonstrator and Lecturer on Anatomy, University of Edinburgh. Seventh edition. $4\frac{1}{8} \times 6\frac{3}{8}$ in. Pp. 736 + viii. 1950. London: Oxford University Press. 18s.

Text-book of Orthopædic Medicine. By JAMES CYRIAX, M.D., B.Ch. (Cantab.), Physician to the Department of Physical Medicine, St. Thomas's Hospital, London. Vol. II, Treatment by Manipulation and Deep Massage. Fourth edition. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Pp. 335 + xvi, with 121 illustrations. 1950. London: Cassell & Co. Ltd. 18s. 6d.

Les Phlébites. Phlébographie clinique et thérapeutique de la Maladie thrombo-embolique. By LUCIEN LEGER and CLAUDE FRILEUX. $6\frac{1}{4} \times 9\frac{3}{4}$ in. Pp. 300, with 85 illustrations. 1950. Paris: Masson et Cie. 1400 fr.

Surgery of the Shoulder. By A. F. DE PALMA, M.D., James Edwards Professor of Orthopædic Surgery and Head of the Department, Jefferson Medical College, Philadelphia; etc. 7 × 10 in. Pp. 438 + xx, with 357 illustrations. 1950. Philadelphia and London: J. B. Lippincott Co. £7.

Diseases of the Heart and Circulation. By PAUL WOOD, O.B.E., M.D., Director, Institute of Cardiology, London; Physician, National Heart Hospital; etc. 6 × $9\frac{5}{8}$ in. Pp. 589 + xxx, with 354 illustrations. 1950. "The Practitioner" Series. London: Eyre & Spottiswoode (Publishers) Ltd. 70s.

Renal Diseases. By E. T. BELL, M.D., Professor of Pathology in the University of Minnesota. Second edition. $5\frac{3}{4} \times 9$ in. Pp. 448, with 123 illustrations and 4 colour plates. 1950. London: Henry Kimpton. 56s.

Degenerazione e Rigenerazione dei Tronchi nervosi nell'Uomo. By Professor SILVANO LEGHISSA, Institute of Comparative Anatomy, University of Bologna. $6\frac{7}{8} \times 9\frac{5}{8}$ in. Pp. 282 + viii, with 179 illustrations, some in colour. 1950. Bologna: Edizioni Scientifiche Istituto Rizzoli. L.4500.

John Hunter. By S. ROODHOUSE GLOYNE, M.D. (Leeds), Consulting Pathologist, London Chest Hospital, and King Edward VII Sanatorium, Midhurst. $6\frac{1}{4} \times 8\frac{5}{8}$ in. Pp. 104 + x, with Frontispiece and 16 Plates. 1950. Edinburgh: E. & S. Livingstone Ltd. 15s.

Aids to Orthopædic Surgery and Fractures. By I. E. ZIEVE, M.A. (Cape Town), F.R.C.S. (Eng.), Chief Surgeon to the Marpeh Izhak Hospital, Nathanya. Third edition. $3\frac{7}{8} \times 6\frac{1}{4}$ in. Pp. 283 + viii. 1950. London: Baillière, Tindall & Cox. 6s. 6d.

Plasma Clot Suture of Peripheral Nerves and Nerve Roots. Rationale and Treatment. By I. M. TARLOV, M.D., Associate Professor of Neurosurgery, New York Medical College, New York City. 6 × 9 in. Pp. 116 + xii, with 47 illustrations. 1950. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell Scientific Publications Ltd.) 40s.

A Synopsis of Anæsthesia. By J. ALFRED LEE, M.R.C.S., L.R.C.P., M.M.S.A., D.A., Consultant Anæsthetist to General Hospital, Southend; etc. Second edition. $4\frac{3}{4} \times 7\frac{1}{4}$ in. Pp. 354 + viii, with 66 illustrations. 1950. Bristol: John Wright & Sons Ltd. 15s.

Chirurgie réparatrice et correctrice des Téguments et des Formes. By L. DUFOURMENTEL. Second edition. $6\frac{1}{4} \times 9\frac{3}{4}$ in. Pp. 400, with 457 illustrations. 1950. Paris: Masson et Cie. 1650 fr.

Injuries of the Knee Joint. By I. S. SMILLIE, O.B.E., Ch.M., F.R.C.S. (Edin.), F.R.F.P.S., Lecturer in Orthopædics in the University of St. Andrews; Surgeon-in-Charge, Eastern Region (Scotland) Orthopædic Service; etc. Second edition. $6\frac{3}{4} \times 9\frac{1}{2}$ in. Pp. 391 + x, with 451 illustrations. 1950. Edinburgh: E. & S. Livingstone Ltd. 50s.

Rest and Pain. By JOHN HILTON, F.R.S., F.R.C.S. Edited by E. W. WALLS, M.D., Ch.B., B.Sc., Professor of Anatomy in the University of London at Middlesex Hospital Medical School; and ELLIOT E. PHILIPP, M.A., M.B., B.Chir., M.R.C.S., M.R.C.O.G., Honorary Demonstrator in Anatomy at Middlesex Hospital Medical School; in collaboration with H. J. B. ATKINS, D.M.M.Ch., F.R.C.S., Director of the Department of Surgery, Guy's Hospital. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Pp. 503 + xxxvi, with 105 illustrations. 1950. London: G. Bell & Sons Ltd. 25s.

Congenital Heart Disease. By J. W. BROWN, M.D. (Lond.), F.R.C.P., Physician to the Grimsby General Hospital; etc. Second edition. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Pp. 344 + xiv, with 128 illustrations. 1950. London: Staples Press Ltd. 30s.

Pain and Its Problems. Edited by Sir HENEAGE OGILVIE, K.B.E., D.M., M.Ch., F.R.C.S., and WILLIAM A. R. THOMSON, M.D. A "Practitioner" Handbook. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Pp. 194. 1950. London: Eyre & Spottiswoode Ltd. (for *The Practitioner*). 12s. 6d.

Pathology in General Practice. By PAUL W. SCHAFER, M.D., Professor of Surgery, University of Kansas School of Medicine. $7\frac{1}{4} \times 10\frac{1}{2}$ in. Pp. 581 + xvi, with 495 illustrations, 368 in colour. 1950. Chicago, Ill.: University of Chicago Press. (London: Cambridge University Press.) £6 11s. 6d.

Principles and Practice of Surgery. By JACOB K. BERMAN, A.B., M.D., F.A.C.S., Associate Professor of Surgery, Indiana, University School of Medicine, Indianapolis. $6\frac{1}{2} \times 9\frac{1}{2}$ in. Pp. 1378 + xvi, with 429 illustrations. 1950. London: Henry Kimpton. £5 5s.

A Surgeon's Fight to Rebuild Men. An Autobiography. By FRED H. ALBEE, M.D., F.A.C.S., F.I.C.S. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Pp. 270, with 11 Plates and 14 text illustrations. 1951. London: Robert Hale Ltd. 15s.

Regional Orthopedic Surgery. By PAUL C. COLONNA, M.D., Professor of Orthopedic Surgery, University of Pennsylvania Medical School. $6\frac{3}{8} \times 9\frac{5}{8}$ in. Pp. 706, with 471 illustrations. 1950. Philadelphia and London: W. B. Saunders Co. 57s. 6d.

Thoracic Surgery. By RICHARD H. SWEET, M.D., Associate Clinical Professor of Surgery, Harvard University Medical School. Illustrations by Torge Rodriguez Arroyo, M.D. $6\frac{3}{8} \times 9\frac{5}{8}$ in. Pp. 345 + xx, with 155 illustrations. 1950. Philadelphia and London: W. B. Saunders Co. 50s.

Fifty Years of Medicine. A Symposium from the *British Medical Journal*. 6 × $9\frac{1}{2}$ in. Pp. 330 + viii. Illustrated. 1950. London: British Medical Association. 15s.